C-130H “Hercules”
Qualification/Evaluation Guide
418 FLTS
Oct 2012
Intentionally Left Blank
CHAPTER 1
AIRCRAFT DESCRIPTION

GENERAL
The C-130, manufactured by the Lockheed Company, is a medium range tactical transport powered by four T-56 turboprop engines. The C-130 can operate from short, unprepared surfaces, can back up under its own power, and has been adapted for many missions, with cargo hauling, airdrop, and medical evacuation as the most common. The aircraft has been in continuous production since 1955 with over 2,300 examples delivered by 2009.

Development of the C-130 was a direct result of the Korean War, as the propeller powered transports left over from WW II were unable to accomplish short take off and landings with useful loads. A development contract was awarded to Lockheed, who produced the YC-130 prototype that first flew on 23 August 1954 from Burbank to Edwards AFB. Unlike transports derived from passenger airliners, the C-130 was to be designed from the ground-up as a combat transport with loading from a ramp at the rear of the fuselage. While the appearance of the C-130 was unremarkable, the design was innovative in introducing 3000 psi hydraulic boosted flight controls, turboprop propulsion, and the high lift capabilities of the Lockheed-Fowler type wing flaps.

DIMENSIONS
<table>
<thead>
<tr>
<th>Wing span</th>
<th>132 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>98 feet</td>
</tr>
<tr>
<td>Tail height</td>
<td>38 feet</td>
</tr>
</tbody>
</table>

WEIGHTS
| Maximum combat weight         | 175,000 pounds |
| Max normal start taxi         | 155,000 pounds |
| Max landing weight            | 155,000 pounds |
| Normal landing weight         | 130,000 pounds |
| Representative operating weight| 88,000 pounds |
| Fuel capacity                 | 61,364 pounds  |

While not considered a true short takeoff and landing (STOL) aircraft, the C-130 can be operated from runways as short as 3,000 feet, and can operate from unimproved surfaces. At weights less than 135,000 lbs, up to 100 passes are permissible on an unimproved surface with a California bearing ratio of 6 – soil consistency of a golf course fairway. The turboprop engines have excellent foreign object damage (FOD) tolerance, and allow the aircraft to back up on its own power, which is important for operations at airfields with limited ramp space. The low cargo floor and ramp allow the aircraft to easily loaded, to include driving vehicles directly into the cargo compartment and combat offloads – offloads of palletized equipment using the aircraft’s own power.

The aircraft is normally flown with a crew of four; pilot, copilot, flight engineer, and loadmaster. The flight engineer runs the aircraft systems, and the loadmaster runs the cargo compartment, to include loading, unloading, center of gravity and weight calculation, passenger minding, and airdrop rigging.
The design has proved versatile. The aircraft has been flown from both poles and has landed and taken off from an aircraft carrier. Some of the C-130 missions include cargo hauling, air drop, bombing, air-to-ground gunnery, drone launching, photo mapping, missile tracking, covert ingress and egress, air evacuation, airborne battle control, electronic warfare, and television broadcasting. The C-130 can carry 90 troops (life raft capability limits the number to 80 for overwater flights) or 64 paratroopers. The record passenger count for the C-130 is 452 set during the evacuation of Vietnam. The C-130A aircraft used on this mission is prominently displayed at the main gate at Little Rock AFB, AR.

RANGE-PAYLOAD
The C-130 is the primary tactical airlifter for the USAF, meaning that the C-130 mission is to deliver materiel within (inter-) the theater of operations. The strategic airlift (deploying forces from the CONUS to the theater) is the responsibility of the C-5, C-17, and Civil Air Reserve Fleet (CRAF). The following is a range-payload diagram for selected air-drop capable mobility aircraft. These data represent theoretical maximum performance, and do not account for operational limitations that affect the range-payload of a specific mission (takeoff temperature and pressure altitude, runway length, required departure climb gradient, maximum landing weights, etc). For example, the two engine aircraft (C-160, C-27J) appear to have better range performance than the four-engine aircraft. The better range performance results from their lighter operating weights (C-160 60,000 lbs, versus C-130 at 82,000 lbs). However, the allowable takeoff gross weight for the C-160 and C-27J is much more limited by the engine-out climb gradient than for the four engine aircraft. Under a given set of takeoff conditions, the four engine aircraft can depart at a significantly higher gross weight, and hence will likely have better cargo or range capability.

The range-payload comparison makes it clear that the C-130 is ill suited for the strategic airlift mission. On a flight from California to Hawaii, the C-130 is capable of carrying only about 9,000 lbs. of cargo at a cruise speed of 0.45 Mach, requiring flight duration of 7+45. The range-payload for the B737-800, a comparably sized turbofan transport currently in production, is also presented, and gives an idea of the degree to which the C-130 range-performance is compromised for the military mission (turboprop propulsion, straight wing, large cross section, cargo handling equipment, and ramp and door).
While the C-130 is capable of carrying 42,000 lbs of cargo, at cargo weights above 36,500 lbs, the aircraft must land with additional fuel in the wings for wing bending relief. At the maximum cargo weight of 42,000 lbs, the required ballast fuel is 16,000 lbs. This additional fuel must be considered unusable until the cargo is unloaded, and results in the flat portion in the upper right hand corner of the C-130’s range payload graph. The C-130J, currently in production, has this same limitation.

The C-130 is limited to maximum landing weight for assault landings of 130,000 lbs. In a tactical situation where fuel must be tankered, the allowable cargo rapidly decreases from the 42,000 lbs. maximum.

Because the original fleet of C-130A and B model aircraft were worn out by the end of the Vietnam war, the advanced medium short takeoff and landing (AMST) program was launched as replacement for the C-130. David Packard, of Hewlett and Packard, the Secretary of Defense when the AMST program was launched, believed in competitive prototyping (“Fly-before-you buy”); contracts were awarded to Boeing and Douglas for two prototypes, the YC-14 and YC-15. These design goals of the AMST aircraft included improvements on C-130: a 2,600 NM unfueled range with a 19-ton payload, a long-range cruising speed of at least 0.75 Mach, and the ability to operate with a 28,000 pound load from a 2,000-foot-long by 60-foot wide runway during the mid-point of the mission. Both prototypes included a cargo compartment wide enough
to accommodate the M60 tank. When the C-130 was designed in the 1950s, the Army had more infantry than armored division. By the mid-70s, the situation was reversed and C-130 could only carry between 35 and 55% of the mechanized or armored division’s combat vehicles.

Both aircraft meet the AMST program specifications. But as the Vietnam War ended, strategic airlift became a higher priority. In 1973, the United States supported Israel with materiel during the Yom Kippur war. Because of the vast distances (6,500 NM each way), lack of air refueling capability, and unavailability of enroute support facilities, the C-5s and C-141 of Military Airlift Command were stretched to the limit. Although the first naval ship brought in more outsized cargo than had been transported by air in the 19 days before hand, it arrived after the end of the war. The overthrow of the Shah of Iran and the Soviet Union invasion of Afghanistan, which placed forces hostile to the US in proximity to the Persian gulf oil fields, caused the US strategic focus to shift war planning from the Europe and its heavy reliance on prepositioned equipment to the ability to deploy a large force anywhere in the world. The ability to carry outsized equipment (helicopters, armored vehicles) became important, as these are high value items and are generally too expensive to preposition, and cannot be carried by commercial aircraft.

To meet the strategic airlift needs of the US in the early 1980s, the C-5A was rewinged and the production line was restarted and 50 C-5Bs produced, the C-141A was stretched into the C-141B, and 60 KC-10s were acquired as tanker with significant cargo capability. The AMST program morphed into the C-X, a strategic airlifter with tactical capability. Using the Douglas YC-15 as a starting point, the C-X program resulted in the C-17. While the Army had based its equipment transportation plans around the C-5, and the C-5 could transport virtually all of the Army’s divisional equipment, the C-5 proved unable to operate out of austere fields and was not able to back up under its own power. This meant it was limited to larger airfields, and an additional means was needed to get the equipment forward to the fight. While primarily a strategic airlifter, the C-17 has impressive tactical capability, due to its powered lift design, ability to operate on semi-prepared surfaces, and ability back up under its own power. With a given cargo weight, C-17 runway requirements for takeoff and landing is comparable to the C-130, and the C-17 can do so after crossing an ocean carrying a M-1 tank. This is the direct delivery mission, a capability that transcends the division of strategic and tactical airlift.

The C-130As and Bs of Vietnam ended up being replaced by C-130Hs, a modestly improved design that was in production from 1974 until the arrival of the C-130J in the mid-1990’s. The continuous acquisition of the C-130 had the unintended benefit that the fleet is of varying age and will not need to be replaced all at once. Replacing a large fleet is an acquisition challenge, the best example being the decade long effort to replace the KC-135.
The C-130 has the advantage over the C-17 in that it is significantly less expensive to operate, at $2,200/flight hour compared to $8,500/flight hour for the C-17 (FY-10 data from Air Force Total Ownership Cost database). After the Arab oil embargos of the 1970’s, the relatively low fuel burn of the C-130 became one of its strongest selling points.

Because of the ubiquitousness of the C-130, US Army brigade combat team equipment has a design requirement to fit into the C-130. The Army has struggled to design capable armored vehicles that can meet the cargo hold size and weight limitations of the C-130. The Stryker, a new class of Army armored vehicles, had a design requirement that it be transported for 1000 NM by the C-130 and arrive ready to fight. While the Army ultimately demonstrated the ability to transport the 38,000 lbs Stryker in the C-130, the C-130 is often not able to meet the range requirement, and the vehicle must be fueled and provisioned before it can conduct combat operations, failing to meet a key operational requirement. Additionally, the C-130 is unable to carry mine resistance ambush protected (MRAP) vehicles.

The complexity and age of the C-130’s propulsion system design is reflected in fleet reliability, which is low compared to other AMC aircraft. The following is AMC overall planning commitment levels (Reference: AMCI 10-202, Mission Reliability Reporting System, Vol 6, Table A2.2):

<table>
<thead>
<tr>
<th>MDS</th>
<th>Normal</th>
<th>Contingency/Surge</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-5</td>
<td>65%</td>
<td>75%</td>
</tr>
<tr>
<td>C-17</td>
<td>85%</td>
<td>90%</td>
</tr>
<tr>
<td>C-130J</td>
<td>75%</td>
<td>85%</td>
</tr>
<tr>
<td>C-130E/H</td>
<td>65%</td>
<td>75%</td>
</tr>
<tr>
<td>KC-135</td>
<td>80%</td>
<td>85%</td>
</tr>
<tr>
<td>KC-10</td>
<td>80%</td>
<td>80%</td>
</tr>
</tbody>
</table>
COCKPIT

C-130H1 or H2 Instrument Panel

C-130H3 Instrument Panel
AERODYNAMIC CHARACTERISTICS
The C-130 is a cantilever high-wing monoplane with a high aspect ratio wing with a tapered trailing edge. The tapered trailing edge reduces wing structural weight by concentrating area, and hence lift, inboard, while maintaining the efficiency of a high aspect ratio. The wing’s airfoil section is a conventional camber airfoil with good low speed lift production.

The high wing is necessary to provide ground clearance for the propellers. This has the advantage of locating the engine inlets well above the ground, providing excellent FOD resistance for operations on unimproved surfaces.

By bathing part of the wing in the wake of the propeller, the wing is able to achieve higher lift coefficients than would otherwise be possible. With the flaps in the takeoff position (50%), the maximum lift coefficients are:

- Power off: 2.2
- Power on: 3.4

Compare these values with the B727 at flaps 40°, which has the highest lift coefficient for a non-powered lift jet transport at 3.0. The C-130 takes advantage of the higher lift coefficient for short field takeoffs.

Power off, the C-130 has benign stall characteristics with sufficient warning via natural airframe buffet. Buffet is noticeable 4 to 15 % above the stall speed, progressing to moderate to heavy buffet at the stall. Stall is characterized by either a pitch down or mild roll-off, depending on how the power is set. Power ON stalls can result in very low indicated airspeeds and high pitch attitudes, which can result in unusual attitudes.

The horizontal tail is fixed, with pitch control provided by an elevator. As a result of the fixed horizontal stabilizer, the aircraft has a relatively narrow center of gravity range that varies with weight.

Laterally, the aircraft is controlled with conventional ailerons located on the outboard trailing edge of the wing. The ailerons produce noticeable adverse yaw that increases as airspeed decreases. Because of the high wing, the aircraft has excellent lateral stability (dihedral effect).

Because of the propeller diameter, the engines are located relatively far out on the wing. As a result, the aircraft has a large vertical tail and powerful single surface rudder to account for engine failures. The Dutch roll mode is well damped throughout the aircraft’s normal envelope.

One unique characteristic of the C-130 is the power effects from the propeller. Longitudinally, the aircraft pitches up when the inboard throttles are advanced and pitches down when the inboard throttles are retarded. With flaps UP, the outboard throttles have little effect on pitch trim. With flaps in the landing position (100%), advancing the outboard throttles causes a pitch down and retarding the throttles causes a pitch up.

All of the propellers turn clockwise when viewed from the rear, resulting in non-symmetric flow around the airframe. As a result, in almost all cases, the No 1 (left outboard) engine/propeller is the critical engine for performance and controllability.
When power is advanced, the aircraft yaws LEFT and RIGHT RUDDER must be applied to keep the aircraft in trim.

The C-130 experiences a marked reduction of directional stability at low dynamic pressures, high power settings, and at elevated side slip angles. This reduction in directional stability is manifested to the pilot as a low rudder force gradient (small rudder forces produce large side slip angles). There are several contributors to this reduction in directional stability, one of which is the normal force produced by the propellers when the propeller is at an angle to the oncoming flow:
Reduction in directional stability at high power settings

The conditions where the reduction in directional stability are most likely to occur are:
- Low speed (aerodynamic controls are less effective, control feel is a function of dynamic pressure)
- Flaps 50% (high rudder boost, allows generation of larger side slip angles)
- Gear up (Landing gear down is stabilizing)
- High power settings (more momentum change across the propeller disk, larger destabilizing normal force)
- Left rudder pedal inputs, right side slip

The primary indication to the pilot of reduced directional stability is the reduction in rudder pedal force gradient. In some cases only 25 pounds of rudder force are needed to command 25 degrees of side slip. The cockpit side forces that might provide warning to the pilot of high side slip are too low to be noticeable at the low airspeeds where rudder force lightening is most likely to happen.

To avoid over control, excessive side slip angles and rudder overbalance (reversal in rudder pedal forces, aka “rudder lock”), the pilot must anticipate and recognize the low rudder force gradient. The pilot will experience the rudder force lightening when the rudder pedals begin to move easily and side slip continues to increase. If the pilot continues with rudder pedal input, the rudder pedal force will continue to decrease until the rudder floats towards full deflection by itself. The pilot experiences this as a reversal in rudder pedal force and it is called rudder overbalance. If rudder overbalance occurs, neutralizing the rudder pedals will not recover the aircraft. The pilot must actively push on the opposite rudder to bring the rudder back towards center. If the rudder is not promptly centered, the airplane can reach an extreme side slip, roll to a high bank angle, and depart controlled flight.
PERFORMANCE
Excess power is a measure of the ability of the aircraft to accelerate or climb. Specific excess power ($P_s$) is the excess power normalized for aircraft weight, allowing the capability of aircraft at different weights to be compared. Compared to a swept-wing jet aircraft, maximum specific excess power for a straight-wing turbo propeller aircraft occurs at much slower speeds in the envelope. The excess power characteristics translate to lower speeds for best angle of climb and best rate of climb for the C-130 relative to swept-wing jet aircraft.

The following diagrams compare the notional characteristics of a swept-wing jet aircraft (black lines) with a straight-wing turboprop aircraft (red lines). This chart shows the differences in total drag between a swept wing and a straight wing aircraft. A straight wing aircraft has less induced drag at slower speeds.
This diagram adds thrust available characteristics from propellers and jet propulsion to the total drag curves. The propeller has highest thrust at slower speeds, with thrust decreasing as airspeed increases. The thrust available from a jet aircraft tends to be relatively constant at subsonic airspeeds:

The following diagram compares the power available and power required between swept-wing jet aircraft and straight-wing propeller aircraft. The straight-wing propeller aircraft has the greatest excess power at slower airspeeds relative to swept-wing jet aircraft:
The contours of constant specific excess power are often presented on a turn performance diagram. A turn diagram is valid for a single thrust to weight ratio; aircraft weight, configuration, power setting, and atmospheric conditions (pressure altitude and temperature). A turn performance diagram presents airspeed ($V$) versus turn rate ($\omega$), with airspeed on the horizontal axis and turn rate on the vertical axis. Overlaid on the chart are lines on constant turn radius ($R$):

\[ R = \frac{V}{\omega} \]

Additionally, curves of constant $n_z$ are overlaid:

\[ N_z = \sqrt{1 + \frac{V^2}{(gR^2)}} \]

The aircraft envelope, defined on the left hand side by the lift boundary (stall speed) and right side by maximum airspeed ($V_{MO}/V_D$) is also presented. The top of the aircraft envelope is the maximum allowable symmetric load factor ($n_z$):
The following is a turn performance diagram for a C-130H at sea level, standard day. 130,000 lbs with thrust set to 1049° C, with contours of specific excess power overlaid.

The highest specific excess power contours are on the left hand side of the aircraft’s envelope near the lift limit (stall speed). The minimum sustainable turn radius is at point “B,” about 1,300 ft (about 12 ship lengths). This is also the point of maximum sustainable turn rate (12°/sec) in level flight. This results in excellent slow speed maneuverability.

The C-130 maximum effort takeoff operations are a result of its specific excess power characteristics. Maximum effort takeoff operations are conducted at significantly slower airspeeds than normal takeoffs to take advantage of the greater specific excess power. The maximum effort speeds provide for improved climb capability at the expense of safety by, in some cases, ignoring minimum control speeds. In the C-130, the actual best angle of climb airspeed (used for clearing obstacles after takeoff) is just above the stall speed. Speeds this slow are not operationally practical, so some speed increment is used at the expense of climb angle.

The C-130 climbout performance is a marked contrast to a typical swept-wing jet aircraft. Using the KC-135R as a representative example of a swept-wing jet aircraft, the following is a diagram of speed/configuration verses climb rate:
Climb gradient is the proportional to the ratio of climb rate to forward airspeed:

For the KC-135R, the climb gradient for a given configuration (flap setting) **increases** with **increasing** airspeed at slow speeds. This is in contrast to the C-130, where climb rate generally **decreases** with **increasing** airspeed at slow speeds.

Relative to a swept-wing jet aircraft, the C-130 has a much larger difference between best rate of climb airspeeds and practical cruise airspeeds. This shows up in C-130 cruise step climbs, where the aircraft is slowed to best rate of climb, the climb is accomplished, and then once level, the aircraft is accelerated at maximum continuous power until reaching the desired cruise airspeed. The cruise airspeed is typically at a very low excess power condition:
An additional area where the C-130 excess specific power characteristics are manifested is during heavy airdrop malfunction procedures when multiple 28-foot extraction parachutes deploy outside the aircraft but do not extract the load. The deployed extraction parachutes result in an extremely high drag condition. The pilot’s procedure for heavy airdrop when multiple 28-foot extraction parachutes deploy outside the aircraft is to set maximum thrust and slow to maximum effort takeoff speed. Looking at the specific excess power contours, maximum effort takeoff speed approximates the region of maximum specific excess power where the aircraft’s climb rate is maximized:

**WARNING**

With multiple 28-foot extraction parachutes deployed outside the aircraft, maximum thrust will be needed to stay aloft or control the descent. The drag produced by the extraction parachutes should decrease if airspeed is allowed to bleed off. This reduction in drag could permit level flight or reduce the rate of descent should level flight not be possible. Do not reduce power to achieve this airspeed change and do not slow below max effort takeoff speed. Max effort takeoff speed is 1.2 x power on stall speed and provides an acceptable airspeed margin for zero bank angle.

Slowing to maximum effort takeoff speed is a compromise; it is an easily computed number and provides some margin above stall.
ENGINES-PROPELLERS
The C-130 is powered by four T56 turboprops that were developed specifically for the C-130. They were one of the first turboprops developed in the West. The turboprop is made up of three main components, a gas generator, reduction gear box, and propeller.

T56 Engine-Gearbox

Turboprops provide gas turbine reliability and power to weight ratios with the good low speed performance of propellers. Turboprops have a sweet spot at speeds below about 400 knots TAS, where they provide better fuel efficiency for a given range/payload target relative to turbofan engines. Turboprop efficiency comes from the propeller accelerating a relatively large amount of mass flow at a relatively low velocity.

Gas Generator
The gas generator, or “engine,” consists of a compressor, combustion, turbine, and exhaust. In a turboprop installation, the majority of the power produced by the gas generator is extracted by the turbine and used to drive the propeller. Because most the energy from combustion is used to drive the turbines, the residual energy in the exhaust jet is low, and the exhaust jet produces typically less than 10% of the total thrust.

\[ \text{ESHP} = \text{BHP} + \frac{T_J \cdot V}{325 \cdot \eta_p} \]

Where:
- \( \text{ESHP} \) = equivalent shaft horsepower
- \( \text{BHP} \) = brake horsepower, or shaft horse power applied to the propeller
- \( T_J \) = jet thrust, lbs.
- \( V \) = velocity, TAS
- \( \eta_p \) = propeller efficiency, percent
Turboprops are rated using power, in units of horsepower (Hp) or kilowatts (KW). For the C-130 with 54H60 propellers under static, standard day, sea level conditions:

\[
\begin{align*}
\text{ESHP} &= 4,910 \text{ horsepower} \\
\text{BHP} &= 4,591 \text{ horsepower} \\
T_j^*V/325*\eta_P &= 319 \text{ horsepower}
\end{align*}
\]

During flight, the T-56 runs at a constant 100% RPM (13,820 RPM), so torque (force times distance) is proportional to horsepower. The C-130 T-56 installation uses torque as the primary indication of engine output. The most important operational limitations for the C-130 engine are:

- Torque: **19,600 in-lbs. maximum**
- Turbine inlet temperature (“TIT”): **1083º maximum**.

The T56-A-15 engine is flat rated (meaning it gives out a constant 19,600 in-lbs. of torque, until the ambient temperature reaches a “break” temperature, and then available torque decreases as temperature increases. Stated another way, **at low ambient temperatures the engine is torque limited by 19,600 in-lbs of torque, and at high ambient temperatures, the engine is TIT limited.**

**Reduction Gear Box**

In order to obtain the mass flows with a reasonable cross section, the compressor of the gas generator is required to operate at high RPM (13,820 RPM for the T56). The propeller sees both the forward velocity of the aircraft and its rotational velocities, therefore the propeller tips approach the speed of sound well before the aircraft itself. Once the propeller tips approach the speed of sound, wave drag increases substantially. In order for a turboprop to be efficient over a practical range of aircraft speeds, the propeller must turn slower than the gas generator. As a result, there is a need for a reduction gear assembly to reduce the rotation speed of the propeller relative to the gas generator. The reduction gear box for the C-130 has a ratio of 13.54 to 1, so the propeller spins at 1,021 RPM at 100% RPM.

**Variable Pitch Propeller**

The angle of attack of a fixed-pitch propeller, and thus its thrust, depends on the forward speed of the aircraft and the rotational velocity. A fixed pitch propeller will provide the maximum
thrust only at a single airspeed. By varying the pitch of the propeller, the best possible efficiency can be realized throughout a range of airspeeds. To be efficient throughout the aircraft’s envelope, the C-130 propeller is variable pitch.

To simplify the compressor aerodynamics of the gas generator, most turboprops, including the T56, are designed to operate in flight at a constant RPM. To increase thrust, fuel is added to the gas generator, and the increase in power is absorbed by increasing the blade angle of the propeller.

Running the gas generator all the time at 100% in flight provides excellent go-around performance, as the there is no spool-up time as is typical with a turbo-fan engine that must accelerate turbo-machinery with a big rotational inertia. All that is required to increase thrust is additional fuel to the gas generator and a small blade angle change. Since a large portion of the wing is bathed in the propeller wash, not only does the thrust increase quickly, the addition of power increases the lift coefficient at a constant angle of attack.

Ground and flight modes: For ground operations, a low pitch angle is required to minimize thrust. Additionally, the ability to operate at negative blade angles provides reverse thrust and the ability to back the aircraft on the ground without creating a FOD hazard. Too high a blade angle makes it difficult to control taxi speed and creates a hazard during engine running on and off loads. For flight operations, higher blade angles are required to ensure the engine propeller combination is producing positive thrust. As a result of the different requirements for blade angle on the ground and in-flight, the C-130 propeller control mechanism has two modes, an “alpha” mode intended for flight or ground operation, and a “beta” mode intended only for ground operation. On the C-130, the position of the throttle within the throttle quadrant determines if the propeller is in alpha or beta mode.
In the ground, or beta range, changes in throttle position affect both fuel flow and propeller blade angle. Within the ground range, the propeller blade angle ranges from maximum reverse to the flight idle position. Below the ground idle position, the blade pitch is changed so that the blades have their leading edge pointing slightly opposite to the direction of flight, allowing reverse thrust to be developed by the propeller. The C-130 uses this feature to slow the aircraft during taxi and after landing.

Reverse thrust can be used on the ground only. Reverse thrust is used to slow the aircraft during rejected takeoffs, landings, and during taxi, both to control taxi speed, and for backing the aircraft up. The ability to back up is important for operations at austere airfields, where there may be limited ramp space.

Reverse thrust under static conditions is about 30% of static takeoff power. The effectiveness of reverse thrust increases with airspeed, so that at 100 knots, reverse thrust is about 60% of static takeoff power.
In addition to the throttles, the C-130H is equipped with a condition lever for each engine to control engine operation and propeller feathering/unfeathering:

![Condition Levers in Run Position](image)

**Condition Levers in Run Position**

**RUN**: (detent position): Allows engine and propeller to operate

**GROUND STOP** (detent position) If the touchdown system is in the ground mode, closes electrical fuel shutoff valve to engine.

**FEATHER** (detent position)
- Sends propeller controls a feather signal
- Operates auxiliary feather motor
- Closes electrical fuel shutoff valve to engine

**AIR START** (condition lever must be held in airstart position):
- Allows engine and propeller to operate (same as RUN)
- Operates auxiliary pump, providing hydraulic pressure to unfeather the propeller

In a variable-pitch propeller, the blades are turned in the hub about their longitudinal or pitch-change axis. The mechanism provided to produce this pitch change must be capable of exerting sufficient force to overcome any mechanical or aerodynamic opposing force set up by the blades themselves. The strongest force is the centrifugal twisting moment (C.T.M). The centrifugal twisting moment is a turning couple brought about by the fact that the blade sections are inclined at an angle to the plane of rotation. The centrifugal twisting moment will cause the heaviest part of the blade, the leading edge, to move in line with the plane of rotation. This serves to decrease blade angle. When the blade pitch is reduced, the propeller torque force (force opposing rotation) is reduced, and if nothing is done to the gas generator (engine), the reduction in propeller torque...
force will cause an over speed. Because of the centrifugal twisting moment, propellers such as the 54H60 require hydraulic pressure to maintain the propeller blade angle. If hydraulic pressure is lost, the propeller will go to fine pitch. If the engine is not operating, the result is very high wind milling drag:

The C-130 T-56A engine and propeller make up a single shaft turboprop, meaning the engine and propeller are mechanically connected. During some flight conditions, especially at high airspeed and low power, during engine control transients, or following engine flameout, the air loads on the propeller cause it to wind mill, providing more torque than is being supplied to the propeller by the engine. The wind milling propeller will drive the engine and all the accessories, resulting in negative torque. Large negative torques causes high drag, resulting in controllability and performance problems and potential engine over-speeds.
In the flight or alpha range, the propeller is governed to a constant 100% RPM, and thrust changes are made by changing fuel flow and blade angle rather than engine speed. Advancing the throttle in the flight range causes an increase in fuel flow which results in an increase in turbine inlet temperature and energy available to the turbine. The turbine extracts more energy from the gas flow and transmits it to the propeller in the form of additional torque. The propeller, in order to maintain governing speed, increases blade angle to absorb the increased torque. Operating the engine at constant RPM improves throttle response, as there is no “spool up” time, and thrust increases can be made by changing blade angle.

Normally, the propellers are governed electronically through the synchrophaser. Electronic governing provides:
- Speed stabilization (rate feedback)
- Throttle anticipation
- Synchrophasing

There is a backup, purely mechanical governing mode. The MECH mode is selected via four guarded switches on the copilot’s side shelf:

At the extreme end of the flight range is the “feather” position where the blade pitch is changed so that the blades have their leading edge pointing into the direction of flight, offering minimum resistance to the airflow. This mode allows the propeller rotation to be stopped, without adding excessive drag to the aircraft. Feather is used to improve the performance of the aircraft after the failure of an engine. In the C-130, there is no auto-feather feature and the feather condition must be commanded by the aircrew, through either the condition lever or fire handle.

The propellers on the C-130 are not counterweighted, and the blade angle will flatten from centrifugal force if hydraulic pressure is not maintained on the blade change mechanism. The propellers must be driven towards feather via valve housing hydraulic pressure. An electrically powered auxiliary feather motor is used to feather the propeller. When the propeller is signaled to feather, either via the condition lever or fire handle, the auxiliary feather motor operates. Operation of the auxiliary feather motor is indicated to the aircrew via solenoid-actuated feather buttons. When the auxiliary feather motor is operating, the feather override button is pulled down and a light illuminates. The crew can pull the feather motor override button out to shut off the feather motor, or push the button in to complete the feather cycle.
Since the engine runs at constant RPM, torque is proportional to power and is used as the primary parameter for engine thrust settings and ratings. Normally, the engine drives the propeller, resulting in positive torque values.

There are two systems within the gearbox that work to mitigate the drag caused by negative torque. The primary means of reducing negative torque is the negative torque system (NTS). If an intermediate value of negative torque is sensed, propeller control is commanded to increase the blade angle (move propeller blades towards feather) to relieve the negative torque. When the propeller is driving the engine, the NTS system tends to engage intermittently, each NTS engagement driving the propeller to a higher blade angle until the negative torque is relieved, then disengaging. Centrifugal force returns the propeller to a lower blade angle, building up negative torque until NTS reengages. The NTS is deactivated when the throttles are moved below flight idle, into the ground (beta) range, to permit reverse thrust.

To back up the NTS, a safety coupling is installed that actuates at a much higher negative torque than the NTS. The safety coupling acts as a mechanical “fuse” that minimizes the drag from a propeller that fails to feather. If an in flight decoupling occurs, the flight manual directs that the engine be immediately shutdown. The power plant is no longer producing thrust.

The C-130’s propeller is equipped with a low pitch stop. The purpose is to prevent the propeller blades from entering the ground (beta) range while the aircraft is in flight. The low pitch stop physically prevents the blade angle from decreasing below 23 degrees with the throttles in the flight (alpha) range. When the throttles are retarded below the flight idle detent, the low pitch stop retracts.

The propeller is also equipped with a pitch lock mechanism. The purpose is to prevent the blade angle from decreasing if propeller hydraulic pressure is lost or the propeller over speeds (indicating loss of speed control). The pitch lock engages if RPM > 103%, and consists of ratchets that lock the propeller at its existing pitch and prevent the blade angle from decreasing. A pitch locked propeller functions as a fixed pitch propeller and can continue to provide thrust with a complete loss of propeller governing fluid.

The T56 fuel control is completely mechanical. To permit use of different fuels with potentially different energy contents, the engines are equipped with a temperature datum (TD) system. The
The temperature datum operates electrically and has limited authority to schedule fuel to maintain target turbine inlet temperatures. When active (TD switches in the AUTO position), the temperature datum system operates in one of three modes:

<table>
<thead>
<tr>
<th>Start Limiting</th>
<th>Temperature Limiting</th>
<th>Temperature Controlling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine RPM &lt; 94%</td>
<td>Engine RPM &gt; 94% and throttle less than 65º throttle lever angle</td>
<td>Engine RPM &gt; 94% and throttle more than 65º throttle lever angle</td>
</tr>
<tr>
<td>Reduces fuel flow when TIT reaches 820 º C to protect 830º C</td>
<td>Reduces fuel flow to protect 1083 º C (Takeoff TIT limit). TD correction lights illuminated.</td>
<td>Schedules TIT as a function of throttle position. Reduces fuel flow to protect 1083 º C (Takeoff TIT limit). TD correction lights extinguished.</td>
</tr>
</tbody>
</table>

As the throttles are advanced in the flight range, there is a distinctive "torque bump" when the TD system kicks into the temperature controlling range at 65 degrees of throttle lever angle. In the temperature controlling range, the TD system schedules TIT with throttle position. If it is necessary to trim the aircraft at conditions where the throttles are near the torque bump, the TD valves may be locked. The engines should not be operated at altitudes or temperatures far from where the TD valves were locked.
Temperature Datum (TD) switches aft of Condition Levers

AUTO (Normal Position): Powers temperature datum system, allowing start limiting, temperature limiting, and temperature controlling modes.

LKD (locked): May be used when the throttles are in the temperature controlling range (above 65° throttle lever angle) and TD correction lights extinguished to “lock in” the existing correction. If an over temperature condition is sensed, the TD system will respond by unlocking the existing fuel correction and reducing fuel flow. The locked position is functional only if the TD system is in the temperature controlling range and TD correction lights extinguished. If LKD is selected with the throttles below the temperature controlling range or with the TD correction lights illuminated, the TD fuel valves are placed in the fixed, nominal bypass position.

NULL: Electrical power removed from TD system, and all fuel valves placed in fixed, nominal bypass position. No overtemperature protection is provided.
FLIGHT CONTROLS

C-1300 Control Yoke and Trim Controls

Flap Controls

The C-130 has conventional flight control surfaces consisting of elevator, ailerons, and a single rudder. Trim is provided in all three axes by electrically powered surface trim tabs. The elevator, ailerons, and rudder are “boosted” by independent hydraulic booster packs, two for each control surface, each powered by independent hydraulic systems. The control boost arrangement uses a “weighting arm” to divide the control surface aerodynamic hinge moment between the pilot and the hydraulic cylinders. The flight control system is reversible, as the control surfaces are mechanically connected to the rudder pedals and yoke, and the control forces felt by the pilot are provided by the aerodynamic loads on the control surface. Retaining some aerodynamic hinge moment for the pilot to work against provides the feel of an unaugmented aircraft (higher forces at higher airspeeds, and buffet through the flight controls), and eliminates the need for an artificial feel system, as well as allowing for manual reversion in the event of a dual hydraulic system failure, albeit with vastly increased control forces. This was state-of-the-art flight control...
design, derived in part from the flight controls of the Lockheed P-80. It would take Boeing another decade to introduce hydraulic flight controls on a transport (B727, 1963 first flight), and only after hiring a retired Lockheed engineer.

The C-130 rudder control power is scheduled as a function of flap position. When the flaps are in the 0-15 percent extended range, the hydraulic pressure to the booster assemblies is reduced to about half the normal value to prevent overload at high speeds. When the flaps are extended beyond 15%, the full system pressure is available to the rudder booster assemblies to provide increased control power at low airspeed.

The aircraft is equipped with large Fowler trailing edge flaps that both increase the camber of the wing and increase the wing area, permitting slower approach speeds.
COMMUNICATIONS
With engines operating, the C-130 is loud both on the outside and interior. When approaching the aircraft with the engines or APU operating, wear foam ear plugs. All flight deck communications are conducted using headsets and the interphone. If you are not wearing a noise cancelling headset, recommend wearing moldable ear plugs (E-A-R or MAX brand) under the headset and turning up the interphone radio volume. This provides the best signal-to-noise ratio for the interphone/radios and some protection from ambient noise. The C-130 uses a low-impedence, single plug military style headset.

There are two interphone systems, a flight interphone (labeled INT on the intercom panel), and a HOT MIC interphone system.

Operation of the flight interphone:
- To listen, pull up the INT switch
- To talk, use the IPH push-to-talk switch on the yoke

Operation of the HOT MIC:
- To listen, pull up the LISTEN switch
- To talk, pull up on the HOT MIC TALK switch. The headset microphone is “hot,” transmitting the pilot’s speech without operation of push to talk switch:

If there is an emergency and you need to speak, press the CALL button and you will transmit on the interphone to all interphone panels regardless of how they are set. When the CALL button is released, you return to your original settings.
The communication radios and nav aids are tuned through the self-contained navigation system (SCNS) control head. After pressing the **TUNE** button on the SCNS control head, you are presented with this screen:

![TUNE 1-3 Screen]

The TUNE 1-3 has a “hot” scratchpad (gray field at the bottom of the screen) that allows the crew to enter frequencies or preset channels to tune the radios.

With an empty scratchpad, pressing the line select key (LSK) corresponding to a radio swaps between 1 and 2 (Example, pressing the top left line select key (LSK 1L) with an empty scratchpad swaps between UHF1 and UHF2).

To clear the scratchpad, press the **CLR** button.

To enter a discrete frequency: Enter a frequency directly (including the decimal point, e.g. “318.1” into the scratchpad and line select it into the appropriate radio.

To enter a preset, type the number of the preset into the scratchpad and line select it into the appropriate radio. For example, to enter preset 20 in UHF-1, enter “20” in the scratchpad and then hit LSK 1L. The actual frequency will be displayed, followed by a slash and the preset number: “308.700/20”

Entry of “0” and line selecting the appropriate radio returns you to the last used frequency/preset.
HYDRAULIC SYSTEMS
The C-130 has two primary hydraulic systems, the utility and booster systems. The utility and booster systems are independent with separate reservoirs, engine-driven power sources, loads, and return lines. The utility hydraulic system is powered by engine driven pumps from engines 1 and 2, while the booster system is powered by engine driven pumps from engines 3 and 4.

There is an AC pump powered auxiliary system used for emergency brakes, alternate extension of the nose gear, and operation of the cargo ramp and door.
CREW COORDINATION/CREW RESOURCE MANAGEMENT
Safe and efficient operation of the C-130 requires teamwork and depends on well understood, ritualized roles and checklist responses. The minimum crew for the C-130 is two pilots and a flight engineer, but the aircraft is usually operated with a loadmaster.

Definitions:
These are the roles when the aircraft is on the ground:
- Pilot: pilot sitting in the left seat
- Copilot: pilot sitting in the right seat

In flight, one pilot is designated as pilot flying (PF). This pilot hand flies the aircraft or operates the autopilot. The pilot flying normally:
- Calls for checklists
- Makes throttle movements
- Calls for configuration changes
- Responds to checklist steps as “Pilot” or “Copilot” as appropriate

The other pilot, designated as pilot not flying (PNF) or pilot monitoring, normally:
- Makes configuration changes (exception: because of their locations, the copilot always moves the landing gear and condition levers)
- Makes and answers radio calls
- Sets up navigation equipment
- Responds to checklist steps as “Pilot” or “Copilot” as appropriate

Note that pilot flying (PF) and Pilot in command (PIC) are not synonymous. The pilot in command is directly responsible for, and is the final authority as to the operation of that aircraft. The PIC provides the leadership and creates an environment in which the other crewmembers are willing participants in the operation of the aircraft. Both pilots need to work together to keep themselves and the rest of the crew informed of the aircraft’s energy state, configuration, and where the aircraft is going and the clearance limits.

The flight engineer (“engineer” or “FE”) is responsible for systems operation and monitoring, calculating performance data, and monitoring the engines.
The loadmaster ("load") is responsible for cargo loading, computing weight and balance, briefing/monitoring or passengers, and operation of cargo compartment airdrop equipment. The load "owns" the cargo compartment. The loadmaster will be on headset prior to engine/APU start to clear each engine prior to start and remove or install wheel chocks.

Checklists
On the ground, the pilot initiates all checklists by stating over interphone: “XXXX checklist”
In flight, the pilot flying (PF) initiates all checklists over interphone.

If the aircraft is moving, the flight engineer reads/runs the checklist.
If the aircraft is stopped, the copilot reads/runs the checklist (exception: the flight engineer runs the STARTING ENGINES checklist).

The checklist is not complete until the crewmember reading/running the checklist states “XXXX Checks complete.”

During emergencies, it is important that one pilot be designated to exclusively fly the aircraft, since it is easy for everyone on the flight deck to become distracted running checklists. A complete set of flight manuals is carried and should be consulted during abnormal situations or emergencies. The remaining crewmembers not flying the aircraft should follow the guidance in the flight manual. Any configuration change (engine shutdown) or irreversible action (disconnecting generators, discharging fire extinguishers) should be coordinated between applicable crewmembers before accomplishment.

Coordination between crewmembers, normally over interphone, will be established prior to:

- Transferring control of the aircraft between pilots
- A crew member leaves position or leaves interphone
- A crewmember goes on or off oxygen
- The pilot performing any critical maneuver, at which time all crewmembers will be secured in their respective positions.
- Changing to a new radio for ATC communications

The interior of the C-130 is noisy and the public address system is not audible with engines or APU running, so effective interphone use by each crewmember is essential for good crew coordination. As it is a single channel of communication, interphone should be held to the minimum required for safe and effective conduct of the mission.
AIRCRAFT LIMIT SUMMARY

Airspeed limits, Clean:

- $V_H$ is the maximum recommended airspeed.
- $V_D$ is the maximum speed.

The coded areas 1, 2, and 3 correspond to different combinations of cargo/fuel loading. For most of the aircraft’s cargo/fuel envelope, the aircraft can be operated using the maximum recommended speed indicated by line 1.

Operations in the region between the maximum recommended and maximum speed should be limited. Do not exceed maximum recommended airspeed in greater than moderate turbulence.

- Flaps 50% ................................................................. 180 KIAS
- Landing gear operating/extended .................................................. 165 KIAS
- Flaps 100% ........................................................................ 145 KIAS
- Ramp and door open ................................................................. 150 KIAS

Maximum load factor, flaps retracted [Recommended area of primary fuel management]
- Symmetrical ......................................................................... 2.5g
- Unsymmetrical ..................................................................... 2.0g

Maximum load factor, flaps extended:
- Symmetrical ......................................................................... 2.0g
- Unsymmetrical ..................................................................... 1.5g

Engine limits
- Maximum torque ................................................................. 19,600 inch-pounds
- Maximum TIT, limited to 5 minutes ....................................... 1049-1083°C
- Maximum TIT, limited to 30 minutes .................................. 1010-1049°C
- Maximum continuous TIT .................................................... 1010°C
CHAPTER 2
NORMAL OPERATIONS

PREFLIGHT
The flight engineer (FE) accomplishes the exterior and interior checks. Once in the seats, the pilots accomplish the following without reference to checklist:

- Check oxygen
- Checks flight instruments and navaids
- Start INS alignment
- Check radios
- Adjusts the seats/rudder pedals

The C-130 cockpit and cargo compartment are a pressure vessel, containing electrical equipment and hydraulic components with the potential to sustain combustion and produce combustion products toxic enough to incapacitate the crew in seconds. The aircrew’s first line of defense is the quick donning oxygen masks installed at each crew station. The oxygen regulators and mask should be carefully checked prior to each flight. Following preflight, the oxygen regulators are left in the 100% O₂ – ON position to provide protection from inhaling smoke/fumes.

The mask hangs outboard of the pilots’ seats:

The quick don mask is designed to be worn over the headset and aircrew eye glasses. The aircrew headset plugs into the quick don, and an integral mask microphone is activated when the blue aluminum sides are rotated outwards from the stowed position.

Not shown in the following diagrams are the smoke goggles attached to the mask, designed to be worn over eye glasses. The oxygen mask is equipped with an eyewash vent to purge the goggles with 100% oxygen. The eyewash valve is located on the top of the nose piece, and provides oxygen to vent the goggles when it is pulled OUT (away from your face).
Eyewash pin in open/extended position
Regulator pressure limits:
- Static: 270-455 psi
- Flowing: 270-340 psi
Any pressure below 50 psi requires an AFTO 781 write-up

Oxygen Preflight:

1. Supply Lever – OFF
2. Diluter Lever – 100% OXYGEN
3. Attempt to breathe. The ability to breath indicates a faulty regulator.
4. Supply Lever - ON
5. Emergency Toggle Lever – EMERGENCY
6. Ensure eyewash pin in IN. Breath 3 cycles, watch blinker for black when breathing in, white when breathing out. Hold breath – blinker should show black, then open eyewash purge valve. A white indication on the blinker indicates the eyewash pin is working normally. Leave eyewash pin OUT.
7. Emergency Toggle Lever – NORMAL
8. Breath 3 cycles, watch blinker for black when breathing in, white when breathing out

Fly with the regulator in following configuration:

- Emergency Toggle Lever – NORMAL
- Diluter Lever -100% OXYGEN
- Supply Lever – ON
Seat and Rudder pedal adjustment
Several different pilot seats have been installed in the 50 year production run of the C-130. The following diagram is representative of seats installed in aircraft built since the late 70’s. The important controls are highlighted below:

1. Adjustable headrest
2. Control column slot
3. Armrest adjustment knob
4. Thigh support control
5. Horizontal adjustment lever
6. Shoulder strap inertial reel lever
7. Horizontal lumbar adjustment
8. Vertical Lumbar adjustment
9. Seat recline lever
10. Vertical adjustment lever

There is no published, standard seating position for the C-130. The pilots should ensure that the seat position provides adequate vision over the glare shield and that the seat is not so far forward that it prevents full aft yoke deflection. Ensure the seat/rudder pedal combination allows for full rudder and brake application.

The C-130 flight controls require relatively light control forces. Many pilots are able to get finer, more precise control by bracing their forearms on the armrests and using their wrists alone to make inputs via the yoke.
Prior to engine start, the left seat pilot will set the parking brake. The placard by the pedals has the following instructions:

To set: Depress pedals and pull handle to hold
To release: Depress pedals

The C-130 parking brake can be difficult to set, use the following expanded instructions for best results:

a. Make sure the pedals are even
b. Depress both pedals fully
c. Pull out on the parking brake handle
d. Slowly release the parking brake handle
e. Ensure pedals remain depressed and are even.

STARTING ENGINES AND BEFORE TAXI
The flight engineer runs the STARTING ENGINES checklist. Normally, the engines are started using bleed air from the APU. Starting order is 3, 4, 2, 1. The pilot starts each engine in turn once cleared by the loadmaster.

(Pilot) – “Clear number [1, 2, 3, 4] engine”
(Loadmaster) – “Number [1, 2, 3, 4] clear”
(Pilot) – Move condition lever to from GROUND STOP to RUN. Engine start is the one exception to the rule that the pilot never touches the condition levers:

(Pilot) – Engage the starter on the forward portion of the overhead panel. Early C-130 starters engage with a pushbutton, while later aircraft have spring loaded toggle switches. Both the pushbutton and switches are spring loaded and need to be held engaged by the pilot. Do not engage the starter if the engine/propeller is rotating, or re-engage the starter if your hand slips off the button/switch.
If a STOP START situation occurs, move the condition lever back to GROUND STOP while keeping the starter engaged. During the start sequence, the starter switch is the last control the pilot touches, so when presented with a STOP START condition, the natural reaction is to “undo” the last action and release the starter. The starter should be kept engaged to purge the engine of combustion products and provide airflow to prevent a stagnation.

During engine start observe:
- Starter light and rotation within 5 seconds of engaging starter switch; if not then STOP START
- 16% RPM - fuel flow indication
- 35% - Ignition (indicated by TIT increase), and gearbox/engine oil pressure; if not then STOP START

60% - (pilot) Release starter switch

By 65% SEC FUEL PRESS light illuminated
<table>
<thead>
<tr>
<th>Condition</th>
<th>Stop Start Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within 5 seconds of start switch actuation</td>
<td>• START VALVE OPEN light does not illuminate</td>
</tr>
<tr>
<td></td>
<td>• No rotation</td>
</tr>
<tr>
<td>35% RPM</td>
<td>• No Fuel Flow</td>
</tr>
<tr>
<td></td>
<td>• No Ignition</td>
</tr>
<tr>
<td></td>
<td>• No Engine or Gearbox oil pressure indication</td>
</tr>
<tr>
<td>Peak TIT &lt; 720</td>
<td>• Low TIT</td>
</tr>
<tr>
<td>Peak TIT &gt; 850</td>
<td>• Hot start</td>
</tr>
<tr>
<td>60 seconds</td>
<td>• On speed (70 seconds in high temperatures)</td>
</tr>
<tr>
<td></td>
<td>• Hydraulic Pressure indication</td>
</tr>
<tr>
<td>On Speed + 30 seconds</td>
<td>• Full hydraulic pump pressure</td>
</tr>
</tbody>
</table>

TAXI
Taxing the C-130 is an acquired skill. In ground idle at 100% RPM, the propellers produce much more thrust than necessary to keep the aircraft at a reasonable taxi speed. The maximum recommend taxi speed on hard surface taxiways is 20 knots. Using wheel brakes alone to control speed will rapidly overheat them. Reverse thrust works to control taxi speed, but in moderate to hot temperatures, the engine oil temperature will quickly rise in reverse and must be carefully monitored to avoid an over temperature. If your aircraft is equipped with oil cooler augmentation, use of reverse thrust has less effect on oil temperature. If the oil temperatures approach the limit, operating an engine at forward thrust (up to flight) idle will be required to provide cooling, which places the aircraft back into a high forward thrust situation. When using reverse, smoothly apply max reverse until you get the desired speed change, then return the throttles to ground idle. If you only go part way back, you are only heating up the oil and won’t see much resultant slowing of the aircraft.

The use of low speed ground idle provides some relief. Low speed ground idle can be obtained by asking the flight engineer to “down speed a pair” or “down speed all four.” The flight engineer engages low speed ground idle (LSGI) by pushing the LSGI buttons located aft of the throttle quadrant. In low speed ground idle, the compressor is unloaded by opening a bleed air valve, resulting in the engine operating at 69–75.5% RPM. Depending on aircraft weight and taxi surfaces, it is generally advantageous to taxi with a pair or all four engines in low speed ground idle. When an engine is in low speed ground idle, the AC generator for that engine is unavailable, so if conditions require all four engines to be down speed, the flight engineer will need to start the APU to provide AC electrical power.

While in low speed ground idle, the pilot has only about two throttle-knob widths of throttle movement either side of the ground idle detent before the engines return to regular ground idle. If the pilot inadvertently advances/retards the throttle out of the low speed ground idle range, the throttle should immediately be returned to the ground idle detent. Popping an engine out of low speed ground idle is bad form in the C-130 community, as an engine bog down/stagnation is possible, especially on hot days or at high density altitudes.
Low speed ground idle range is 9-30° of throttle travel

The C-130 does not have rudder pedal steering, so all taxing must be accomplished by the left seat pilot using the steering tiller:

![Steering Tiller]

**CAUTION**

Turns with brakes locked on one side are prohibited. **When possible, avoid braking in turns, since damage to gear and/or support structures may result.** If a stop, sudden or severe brake application has occurred in a turn, record on Form 781.
Taxi summary:
- Don’t stop in a turn
- Minimize braking in turn
- Bigger the turn, slower the speed
- Before the turn, be slower than you think you need to be
- Maximum taxi speed is 20 knots

Use of wheel brakes
The first 30-40 degrees of pedal deflection do nothing, then a little additional deflection will cause sudden application of the brakes. As the loadmaster may be walking around conducting duties when taxiing, if taxi conditions permit, be gentle with brake application. Many pilots will announce over interphone when they applying brakes to give the loadmasters a chance to brace. To keep your brakes from overheating during a long taxi, make a smooth, continuous, and increasing pressure brake application to slow the aircraft down to a crawl (3-5 knots), then let the speed build up again.

Upon completion of the Before Taxi checklist, the left seat pilot will release the parking brake. Hold the brakes until the marshaller signals that the aircraft is clear to proceed. If the plane has been sitting for awhile, you may need a couple knob-widths of power to get started. Once you notice the plane begin to move, reduce power immediately to ground idle (or just above if you are really heavy). Test your brakes by lightly applying pressure to the toes.

Initial turns out of parking should be slow and controlled. More than 5 knots and you are probably speeding. If the pavement is dry, you can probably use the nose wheel steering exclusively, but it never hurts to use a little outside throttle (1 throttle, 1 knob-width) to help keep your momentum. Keep the speed slow and use spotters in the cockpit, side windows, overhead escape hatch, or marshalls outside the plane to keep clear of obstacles.
TAKEOFF
The Flight Engineer computes takeoff and landing data (TOLD) and provides a pilot information card. The takeoff data is shown on the left side of the card, landing data in the center. The important speeds (takeoff, two-engine VMCA) should be memorized before takeoff:

The takeoff thrust setting used to compute the takeoff data is shown in the upper left, and consists of both a TIT and torque setting. For light weight takeoffs, reduced thrust is used (TIT set to 970 or 1010). When a reduced thrust takeoff is performed, the pilot sets the target TIT, however, it is important to make sure you crosscheck that the engines are all meeting the predicted torques.

When a full power takeoff is required, the engines should be set prior to brake release if possible. Because of the torque increases ~600 inch-pounds as the aircraft accelerates (“Ram rise”), 18,800-19,000 inch –pounds should be set statically. When full power is required, both engine limitations must be closely monitored to avoid exceedances:

- Torque: **19,600** in-lbs. maximum
- Turbine inlet temperature (“TIT”): **1083°** maximum.

A normally functioning temperature datum (TD) system will protect the **1083°** maximum TIT limit. **There is no protection of the 19,600 in-lbs maximum torque limit**, and at cooler ambient temperatures the characteristics of the engine make it easy to exceed **19,600** in-lbs and over torque the engine.

The torque indication lags throttle advancement, so it is very easy to overshoot the intended torque. At the extreme forward thrust position, the torque output is very sensitive to small throttle movements. **Advance the throttles at a maximum of 1 inch/sec.** The fuel control is mechanical/analog and responds slowly compared to modern fuel controls. When advancing to maximum thrust, slow the rate of advance as you get close to the torque limits. The following diagram shows a 1,200 to 1,500 inch-pound torque overshoot (red line) from a flight idle to takeoff power throttle transient. The throttle was moved from flight idle to takeoff power in 2 seconds:
As the throttles are advanced beyond 65° in the flight range, there is a distinctive "torque bump" when the TD system transitions to the temperature controlling mode, where TIT becomes a function of throttle position.

If wind gusts are called, increase rotate, takeoff, approach, threshold, and touchdown speeds by the full gust increment up to a maximum of 10 knots.

Since the C-130 does not have rudder pedal nose wheel steering, coordination is required during both left and right seat takeoffs to assure that one pilot is controlling the yoke at all times during the takeoff roll:
Left Seat Takeoff

<table>
<thead>
<tr>
<th>Pilot</th>
<th>Copilot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At start of takeoff run:</strong></td>
<td><strong>At start of takeoff run:</strong></td>
</tr>
<tr>
<td>Left hand: steering tiller</td>
<td>Right hand: Control yoke, forward pressure and aileron into the wind</td>
</tr>
<tr>
<td>Right hand: throttles</td>
<td>Feet: guard rudders/brakes</td>
</tr>
<tr>
<td>Feet: on rudders/brakes</td>
<td>Feet: on rudders/brakes</td>
</tr>
</tbody>
</table>

When pilot is able to maintain directional control with rudder alone (usually 60-70 knots):

| Moves left hand from tiller to yoke and states: “**Pilot’s controls**” | Relinquishes yoke to pilot |

Right Seat Takeoff

<table>
<thead>
<tr>
<th>Pilot</th>
<th>Copilot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At start of takeoff run:</strong></td>
<td><strong>At start of takeoff run:</strong></td>
</tr>
<tr>
<td>Left hand: steering tiller</td>
<td>Left hand: advances throttles</td>
</tr>
<tr>
<td>Right hand: guards throttles</td>
<td>Right hand: Control yoke, forward pressure and aileron into the wind</td>
</tr>
<tr>
<td>Feet: Guard rudders/brakes</td>
<td>Feet: on rudders/brakes</td>
</tr>
</tbody>
</table>

When copilot is able to maintain directional control with rudder alone (usually 60-70 knots):

| CP: “**Copilot’s controls**” | Removes left hand from tiller |

**Remainder of takeoff roll, all takeoffs**

<table>
<thead>
<tr>
<th>Normal</th>
<th>Obstacle Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Begin rotation at 5 knots below VTO</td>
<td>Pitch to maintain Obstacle clearance airspeed</td>
</tr>
<tr>
<td>• (PM) at VGO, Call “GO”</td>
<td>Maintain obstacle clearance speed until clear of obstacle</td>
</tr>
<tr>
<td>• Rotate to a target pitch attitude of 7°</td>
<td>Once gear has retracted (~19 seconds) and at a minimum of obstacle clearance airspeed</td>
</tr>
<tr>
<td>• With two positive climb indications, “<strong>Gear Up</strong>”</td>
<td></td>
</tr>
</tbody>
</table>

- “**Flaps Up**”, or
- [Technique]“**Flaps 20**”
  - At 2E VMCA
- “**Flaps Up, After Takeoff Checklist**”

Since the landing gear and flaps are both powered by the same hydraulic system, do not actuate both simultaneously. It takes the landing gear about 19 seconds to retract once the handle is placed in the up position, during which time the pilot can accelerate the aircraft to flap retraction airspeed (VTO + 20 knots).
Technique: to aid in the identification of skewed flaps (for which there is no protection), do not call for the flaps to be moved unless stabilized at a stable bank.

It is common C-130 technique to delay retracting the flaps above 20% until the airspeed reaches at least two engine VMCA. This will provide high range rudder pressure and much improved control authority in the event of an engine/propeller malfunction at lower speeds.

Normal Takeoff

After Takeoff
After the flaps are retracted, the pilot flying (PF) calls for the “AFTER TAKEOFF” checklist. The flight manual climb profile:

- 180 KIAS to 10,000 feet
- 170 KIAS from 10,000 feet to 15,000 feet
- 160 KIAS from 15,000 feet to 25,000 feet
- Performance charts above 25,000 feet

Descent
If the throttles are pulled to flight idle at low altitudes and airspeeds, the aerodynamic loads on the propeller may cause it to start driving the gas compressor. Activation of the negative torque system (NTS) may be the result. NTS operation is indicated by oscillating torque, slight aircraft yaw oscillations, and illumination of the NTS light on the copilot’s side shelf. NTS actuation occurs most often when the throttles are at flight idle and the aircraft is in a descent. Usually the NTS will engage on one or two engines before the others.

When NTS engages, the propeller controls drive the propeller blade angle towards feather. With older versions of the NTS, the mechanism could stick, driving the propeller completely to feather and flaming out the engine. The C-130 community has developed the habit of avoiding all but intermittent operation of NTS. NTS operation may cause the nose to oscillate back and forth a little. When NTS engages, the FE will call for that engine's throttle to be bumped up to get the propeller into positive torque.
PATTERN PROCEDURES
The C-130 is normally in instrument approach category C, unless final approach speed exceeds 140 KIAS. The Flight Engineer will compute landing speeds and post the speeds to a card:

| Technique | to aid in the identification of skewed flaps (for which there is no protection), do not call for the flaps to be moved unless stabilized at a stable bank. |

LANDINGS
The C-130 may be safely landed with flaps up, 50% or 100%. Normal settings are 50% and 100%. No flap landings for training are limited to an aircraft gross weight of 120,000 lbs. or less.
The aircraft has low excess power with flaps 100%, so most pilots will fly instrument approaches/visual patterns with the flaps at 50%, selecting 100% flaps on short final. When transitioning from 50 to 100% flaps, there is large nose down pitch trim change, and the aircraft decelerates quickly unless power is added.

The touchdown attitude with flaps 100% is nearly level, and if the touchdown speed is increased for any reason, it is possible to land nose wheel first. As a result of these destabilizing characteristics, most pilots prefer land with 50% flaps unless stopping distance is critical.

The flight manual recommends 50% flaps in strong crosswinds. In crosswinds, the C-130 may be landed using either the wing low or via rudder input in the flare.

To land using the wing low technique, on short final align the fuselage with the runway using rudder. Apply bank angle as required to kill the sideways drift. The aircraft will be flying in a side slip, and the extra drag must be accounted for during flare and power pull.

To land via rudder input in the flare, fly the aircraft on a drift killed heading until in the flare. As the aircraft is about to touchdown, input downwind rudder to align the fuselage with the runway. The main landing gear should touchdown before appreciable lateral drift builds up. If it becomes apparent the aircraft will touchdown in more than 5 degrees of crab, go around.

With 50% and 100% flaps, the landing flare is started 20-30 feet above the runway. As the flare is initiated, the throttles are slowly retarded to flight idle. The C-130 wing is in the propeller wake, so an early or abrupt throttle chop may result in a firm or hard touchdown.

No flap approaches are flown at a much higher pitch attitude than 50/100% flap approaches. When flying a no-flap approach, it is easy to gain speed and hard to lose speed. There is less of a landing flare, and caution must be exercised not to exceed 10 degrees pitch up at touchdown or a tail strike may result. The nose wheel should be held off the runway until the groundspeed decreases below 139 knots to avoid exceeding the tire placard.
TOUCH AND GOS
Flaps are set to 50% for all touch and gos, regardless of the flap setting used for the landing. The power is left in flight idle until the flaps and trim have been reset.

<table>
<thead>
<tr>
<th>Pilot flying</th>
<th>Pilot Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yoke hand:</strong> put aircraft in three point attitude and continue to fly yoke</td>
<td></td>
</tr>
<tr>
<td><strong>Throttle hand:</strong> throttles to flight idle (power remains at flight idle until flaps and trim are reset)</td>
<td></td>
</tr>
<tr>
<td><strong>Feet:</strong> Rudders</td>
<td>Reset flaps to 50% Reset elevator trim to zero</td>
</tr>
<tr>
<td>“Flaps 50%, reset trim”</td>
<td>“Flaps set 50%, trim set, power”</td>
</tr>
<tr>
<td><strong>Throttle hand:</strong> advance throttles to takeoff power</td>
<td></td>
</tr>
<tr>
<td><strong>Yoke hand</strong> Rotate at $V_{ROT}$ or greater</td>
<td></td>
</tr>
</tbody>
</table>

Following main gear touchdown:
(PF) Derotate into three point attitude
(PM) “Flaps 50%, trim” (PM) resets flaps to 50% and resets pitch trim to 0

Once flaps/trim set:
(PF) Advance throttles
(E) “Power set”

When airspeed > VTO, PF rotates to 7 degrees

Retract landing gear/flaps following takeoff procedure, or if staying in visual pattern, leave aircraft configured:
PF: “Touch and go after takeoff checklist”

C-130 Touch and go Procedure
### GO-AROUND

<table>
<thead>
<tr>
<th>4 Engine</th>
<th>3 Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Crew, Going around”</strong></td>
<td>Simultaneously:</td>
</tr>
</tbody>
</table>

- Advance power as required, >900 TIT
- Once power is set and aircraft is climbing, **“Check/set flaps 50”**

If departing or entering radar pattern:

- Two positive climb indications – **“Gear Up”**

Once gear has retracted (~19 seconds) and at VTO + 20 knots
- **“Flaps 20”**

At 2E VMCA:
- **“Flaps Up”**

**“(Touch and go) After Takeoff Checklist”**

If remaining in VFR pattern:

- Accelerate to 170 KIAS
- **“(Touch and go) After Takeoff Checklist”**

Once power is set, [technique: target 200-500 fpm climb and allow aircraft to accelerate. Higher climb rates will cause the airspeed to stagnate.]

- **“Check/set flaps 50”**
- Two positive climb indications – **“Gear Up”**

Control pitch to maintain a 300-500 fpm climb, allowing aircraft to accelerate to 3E climb speed.

Once gear has retracted (~19 seconds) and at VTO + 20 knots
- **“Flaps 20”**

At 2E VMCA:
- **“Flaps Up”**

**At 3E Climb Speed**
- Set 1010 °C TIT
  - **“(Touch and go) After Takeoff Checklist””**

---

- Advance power towards maximum. Stop when reaching:
  - 1010° C TIT
  - 19,600 in-lbs.
  - Full throttle
- Lead with rudder. Step on the ball
- Bank 5 ° away from inoperative engine (“Raise the dead”). Proper engine out trim:
FULL STOP LANDINGS
The transition from flight to ground range is critical, as a propeller stuck in the flight range with the others in ground range will produce a yawing moment that can cause loss of directional control on landing or rejected takeoff. The yawing moment is controllable in ground idle, and rapidly gets worse as the correctly operating propellers are brought into the reserve range. There is no indication to the aircrew prior to feeling the asymmetric drag of the propeller stuck in the flight range. The pilot should pause in ground idle to allow the flight engineer to detect any malfunctions before reversing.

Since the C-130 does not have rudder pedal nose wheel steering, coordination is required during full stop landings to assure that one pilot is controlling the yoke at all times:

Left seat full stop landing

<table>
<thead>
<tr>
<th>Pilot</th>
<th>Copilot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left hand:</strong></td>
<td>put aircraft in three point attitude and continue to fly yoke</td>
</tr>
<tr>
<td><strong>Right hand:</strong></td>
<td>throttles to flight idle</td>
</tr>
<tr>
<td><strong>Feet:</strong></td>
<td>Rudders/brakes</td>
</tr>
<tr>
<td></td>
<td>“Your yoke”</td>
</tr>
<tr>
<td><strong>Left hand:</strong></td>
<td>nosewheel steering</td>
</tr>
<tr>
<td><strong>Right hand:</strong></td>
<td>throttles to ground idle</td>
</tr>
<tr>
<td><strong>Right hand:</strong></td>
<td>Move throttles to reverse</td>
</tr>
</tbody>
</table>

Right seat full stop landing

<table>
<thead>
<tr>
<th>Pilot</th>
<th>Copilot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left hand:</strong></td>
<td>nosewheel steering</td>
</tr>
<tr>
<td><strong>Right hand:</strong></td>
<td>put aircraft in three point attitude and continue to fly yoke</td>
</tr>
<tr>
<td><strong>Left hand:</strong></td>
<td>throttles to flight idle</td>
</tr>
<tr>
<td><strong>Feet:</strong></td>
<td>Rudders/brakes</td>
</tr>
<tr>
<td></td>
<td>“Your aircraft, my yoke”</td>
</tr>
<tr>
<td><strong>Right hand:</strong></td>
<td>Yoke, maintain wings level</td>
</tr>
<tr>
<td><strong>Optional FE:</strong></td>
<td>“All 4/inbounds/outboards”</td>
</tr>
</tbody>
</table>
ENGINE RUNNING ON/OFF LOAD
The LM will deplane out the crew entrance door, and create a barrier with his intercom/headset cord. Personnel should enter and exit FORWARD of the LM’s cord as shown below:
CHAPTER 3
EMERGENCY PROCEDURES

This section only addresses the most serious emergencies requiring immediate action to control the flight path of the aircraft and is in no way comprehensive or complete.

GROUND EGRESS
If in a pilot seat:
- Set the Parking Brake
- Call for Help
- Shut down the aircraft
- Exit the aircraft through the crew entrance door (primary)

Signals for Emergency Egress
“Bailout, Bailout, Bailout” over interphone or public address, or long, sustained alarm bell

If in the cargo compartment follow Loadmaster’s Instructions
- Exit the crew entry door if possible
- Exit paratroop doors, circle to in front of aircraft, remain clear of responding fire fighting vehicles
- **Remain with Pilot for headcount**
DIRECTIONAL CONTROL PROBLEMS WITH THROTTLES IN GROUND RANGE (INCLUDES LOW PITCH STOP FAILS TO RETRACT ON LANDING ROLL).

**WARNING**

After touchdown, if the throttles are moved into the ground range with a movement that is too rapid, it is possible to lose control of the airplane before a propeller malfunction can be detected. **The movement from the flight range should be made at a reasonable rate which will permit detection of a malfunction, such as a failure of the low pitch stop to retract.** The failure of one or more propellers to reverse may result in complete loss of directional control. Landing: at the first indication of directional control difficulties during reversing, immediately return all throttles to GROUND IDLE. Maintain directional control with flight controls differential braking, and as airspeed decreases, nose wheel steering. After identifying the affected propeller, symmetrical propellers may be reversed and the affected engine shut down while it is in ground idle. Rudder, differential power, and brakes are the primary means of directional control until nose wheel steering becomes more effective.

1. Throttles –ground idle
2. Condition lever – “FEATHER”:
3. Reverse symmetric engines and apply brakes as required.
TAKEOFF ABORT
Directional control problems with throttles in FLIGHT range
Engine failure
1. Throttles- flight idle
2. Condition lever – feather

WARNING
If aborting got a propeller malfunction or for any other malfunction which could result in asymmetric power causing directional control problems when the throttles are in the ground range, shut down the affected engine while the throttle is in FLIGHT IDLE. Directional control problems may be encountered if throttles are placed in the ground range and a malfunction prevents the affected propeller from entering the ground range, or if engine power is abnormal.

Technique: To avoid directional control problems, runway permitting, delay putting throttles into the ground range until as low as possible (< 60 knots ideal), runway distance permitting. Refusal speed is based on immediate and full application of the wheel brakes. It is common practice on long runways to use symmetric reverse thrust as much as possible before applying the brakes. Note that the critical field length and refusal speed calculations assume prompt, maximum effort braking. Reverse thrust is most effective at higher speeds.

3. Throttles-ground idle
4. Reverse symmetric engines and brakes as required
5. If required, initiate or continue with ENGINE SHUTDOWN PROCEDURE after safe control of the airplane is assured.

TAKEOFF CONTINUED WITH ENGINE FAILURE OR PROPELLER MALFUNCTION

Maintain directional control with flight controls and engine power as necessary

When fire is not indicated with a propeller malfunction, it is recommended that the engine be allowed to run until at least two-engine VMCA.

Is the engine producing thrust?
Decoupling indicated by really low TIT, fuel flow, and torque.
THREE ENGINE LANDINGS
Three engine landings are accomplished using the same procedures as normal landings, except that the flaps should not be extended beyond 50% until landing is assured. On approach, the rudder must be coordinated with any throttle movements for the asymmetric operating engine. Reverse thrust should be selected only on the symmetric pair of operating engines (inboard or outboard).

TERRAIN WARNING/WIND SHEAR ESCAPE MANEUVER
1. Immediately and simultaneously rotate aircraft 7 degrees nose up and roll wings level
2. Add maximum power
Departure/Approach
   Flaps Up: No less than flaps up approach speed
   Flaps 50/100: No slower than obstacle clearance speed
Enroute
   Flaps Up: No less than 160 KIAS
   Flaps 50/100: No slower than 130 KIAS