1. **PURPOSE: Provide basic information for ALMA G2**

2. **QUALITY RECORDS: Verify document is latest version before use.**

3. **TRAINING**

    1. **Why has Pergam expended resources to document any of the items in all of these documents?**

    All the material has been added to ensure a high quality product is delivered to customers as cost effectively as possible. Some material may not seem relevant or important until the time they are needed.

    2. **What is quality and how do you ensure its delivery to customers using training, procedures, reliable equipment, support, tools, etc.?**

    All previous electronic and paper versions not including signed copies must be destroyed. It is the responsibility of the next person to use an ALMA to update the documentation.

    3. **What is ALMA?**

    ALMA, Airborne Laser Methane Assessment, is an instrument for remote detection of an increased methane gas concentration in ambient air (the gas cloud coming from a leak or other sources) from helicopters.

    4. **Why does ALMA exist?**

    To greatly increase the effectiveness of the gas leak inspection performed by gas companies resulting in safer and more environmentally friendly pipeline systems.

    5. **What is ALMA G2?**

    ALMA G2, Airborne Laser Methane Assessment Generation 2, has a 2.5 times faster scanning rate, 50% more Laser power from better optics, simplified design, and has been constructed per aviation standards compared to ALMA G1 that was used for RMOTC testing (USA Department of Transportation Rocky Mountain Oil Testing Center).

JetRanger with ALMA G2 Optical Unit (grey) Mounted to Belly

6. What is a STC and why is it important?

STC stands for Supplemental Type Certification and signifies that a change to the helicopter (in this case the installation of the ALMA G2) has been approved by an Aviation authority (EASA, FAA, etc.).

Part of the immense STC documentation package are to critical documents that must be followed and onboard the helicopter when ALMA G2 is install.

- STC Certification Document
- Instructions for Continued Airworthiness (ICA): How to install, maintain, etc. the change (ALMA G2 system) to promote safe operation of the helicopter.
- Flight Manual Supplement (FMS): Information for pilot to operate the helicopter with change (ALMA G2 installed)

7. What are the types of ALMA G2 and how to tell which is which?

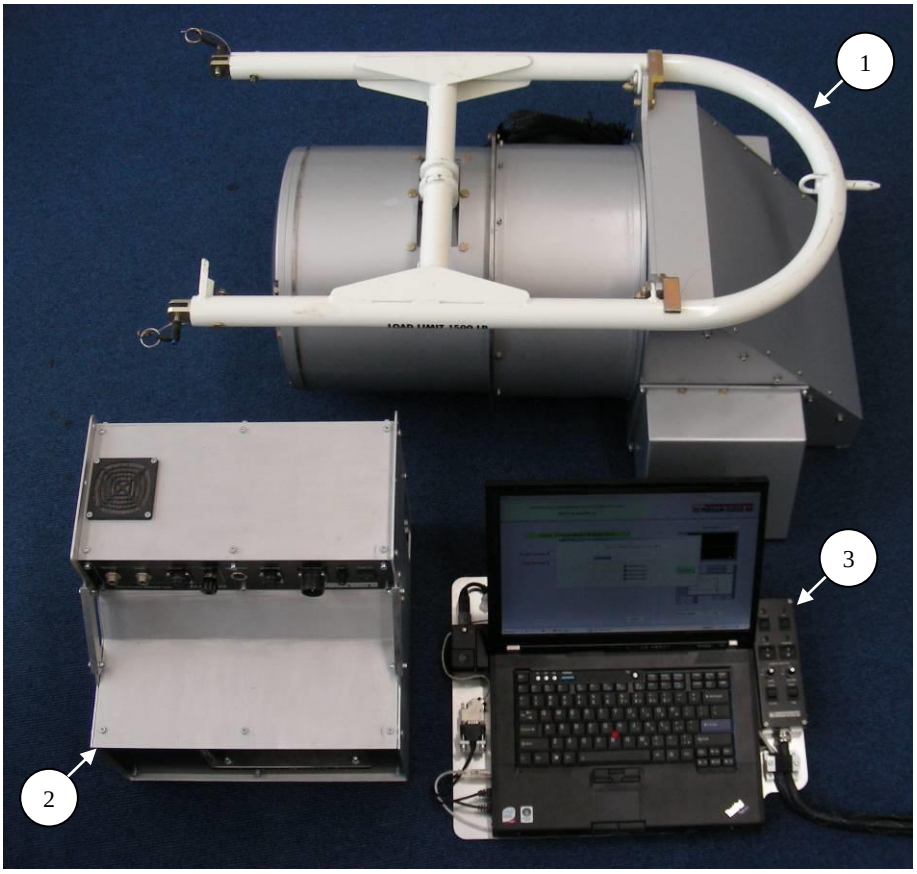
- For JetRanger with STC
  - Even numbered G2/6, G2/8, G2/10, etc..
- For JetRanger without STC
  - G2/5 and G2/7.
- For Other Helicopter (Normally R44) without STC
  - G2/1 and G2/3.

Note: Systems without a STC require special approval to fly on helicopter which is not responsibility of Pergam-Suisse Technical Department

8. What are the parts of ALMA and what are they for?

The ALMA G2 system consists:

1. Optical Unit: Housing the Laser, optics, photodetectors, mirrors, rangefinder, and cameras
2. D-Box: Housing the power distribution, digital video recorder (DVR) and electronics
3. Laptop with C-Box (Control Panel) & GPS: Main computer with user interface, data recording & post inspection data analysis
4. Pilot Monitor: Helps pilot aim Laser – Not pictured below



ALMA G2

9. What are GPS, GPS Accuracy, GPS Error, number of GPS Satellites needed, DGPS, SBAS, WAAS, MSAS, and EGNOS?

GPS is a space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth. The term 'global navigation satellite system' (GNSS) refers to a constellation of satellites providing signals from space transmitting positioning and timing data. The USA's NAVSTAR Global Positioning System (GPS) and Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) are examples of GNSS. Europe is in the process of launching its own independent GNSS, Galileo.

How accurate the GPS reported position to actual position depends on the quality of the equipment, the number of GPS satellites, and availability of location specific augmented (correction) data. GPS Error is a calculated radius for a circle around the report position where the actual position must be within and is based on the quality of the information provided.

Minimum number of unobstructed line-of-sight contact to satellites for GPS position lock is 4. The accuracy of the position lock improves with more satellites.

There are 2 common locations specific augmented (correction) data. Ground stations located strategically calculate the error and provide correction data. DGPS is normally not a gratis service based on a land based communication network. Satellite-based augmentation system (SBAS) is a gratis service based on a satellite based communication network.

Several countries have implemented their own SBAS. Europe has the European Geostationary Navigation Overlay Service (EGNOS). The USA has its Wide Area Augmentation System (WAAS). Japan is covered by its Multi-Functional Satellite Augmentation System (MSAS).

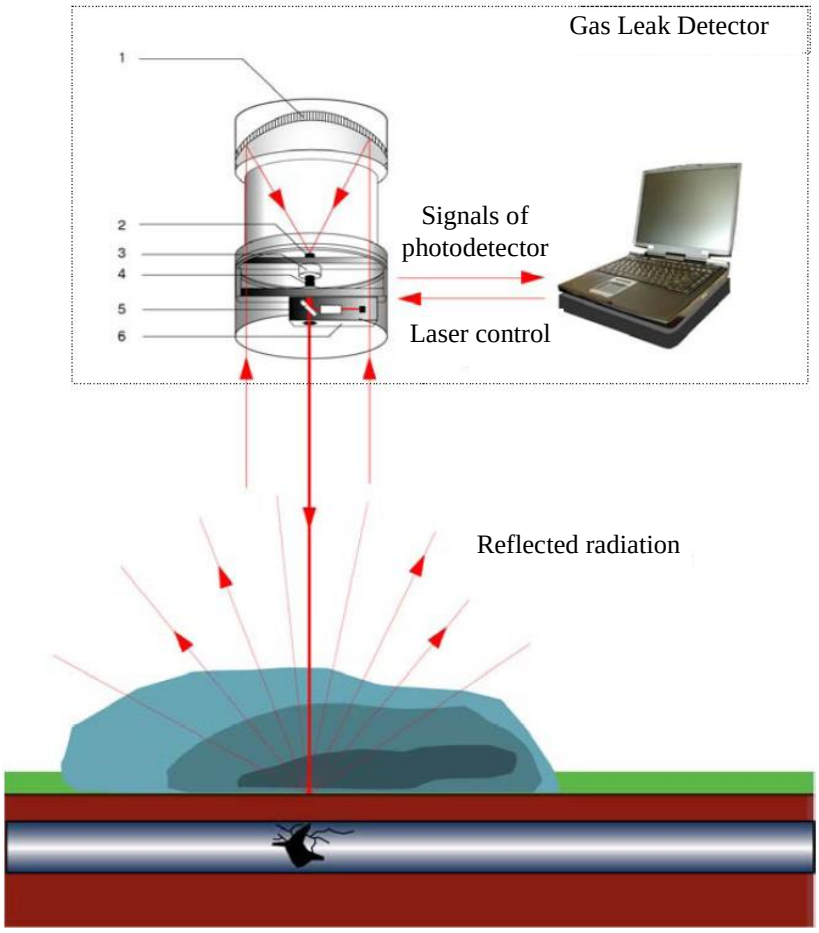
The standard accuracy of about 15 meters (49 feet) can be augmented to 3–5 meters (9.8–16.4 ft) with DGPS, and to about 3 meters (9.8 feet) with WAAS.

10. ALMA G2's GPS Specifications?

Update Rate: 5Hz
Accuracy: <3m / 10ft with WAAS/SBAS

11. How does ALMA G2 detect natural gas leaks?

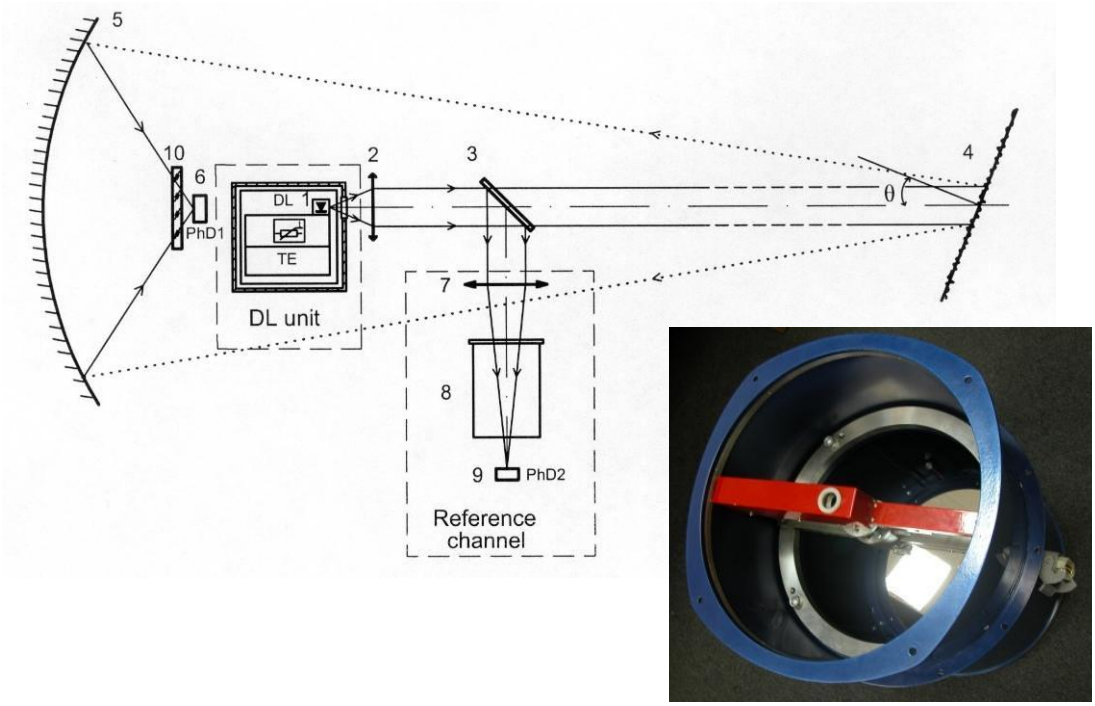
The ALMA is based on an infrared Laser with output radiation wavelength in vicinity of 1650 nm of which Methane absorbs. A Laser beam is emitted from the Optical Unit (OU) and hits a topographic object (soil, grass, trees, concrete, asphalt, etc.). The Laser emits a rainbow of infrared with the wavelength absorbed by methane in the middle. The system analyzes the Laser light back scatter to determine how much if any of the Laser energy was absorbed by the methane in natural gas based on comparing to the other wavelengths emitted. Natural gas is normally at least 90% methane. A unique detection algorithm allows for real-time measurement of total methane content along the Laser light path from the OU to the topographic object.



ALMA OU Diagram of Operation
1 – Receiving mirror
2 – Photodetector
3 – Laser
4 – Objective
5 – Beam splitter
6 – Reference channel

The diode Laser [1] emits in pulse mode through specially coated focusing optics [2]. The Laser radiation wavelength is scanned (varied) in each pulse in vicinity of 1650 nm, where methane has strong absorption lines. The Laser radiation is reflected by a topographical object [4] (soil, grass, trees, etc.); part of reflected radiation is captured by the receiving parabolic mirror [5] and focused through an optical filter [10] (greatly reduces amount of unwanted light) onto the photodetector [6]. In the analytical channel the photodetector converts the radiation into an analog electrical signal which is then amplified. An I/O card from NI converts the analog electrical signal to a digital signal. An algorithm measures the difference in the amount of radiation returned at different wavelengths to determine how much energy was absorbed by methane. In the reference channel a portion of the Laser radiation is split off via optical splitter [3] from the main beam and passed through the reference cell [8] (filled with a methane-nitrogen mixture). The radiation exiting the reference cell is converted to an analog electrical signal in a second photodetector [9], amplified, and then converted to a digital signal. The reference channel signal is used to tune the Laser output to the correct wavelengths.

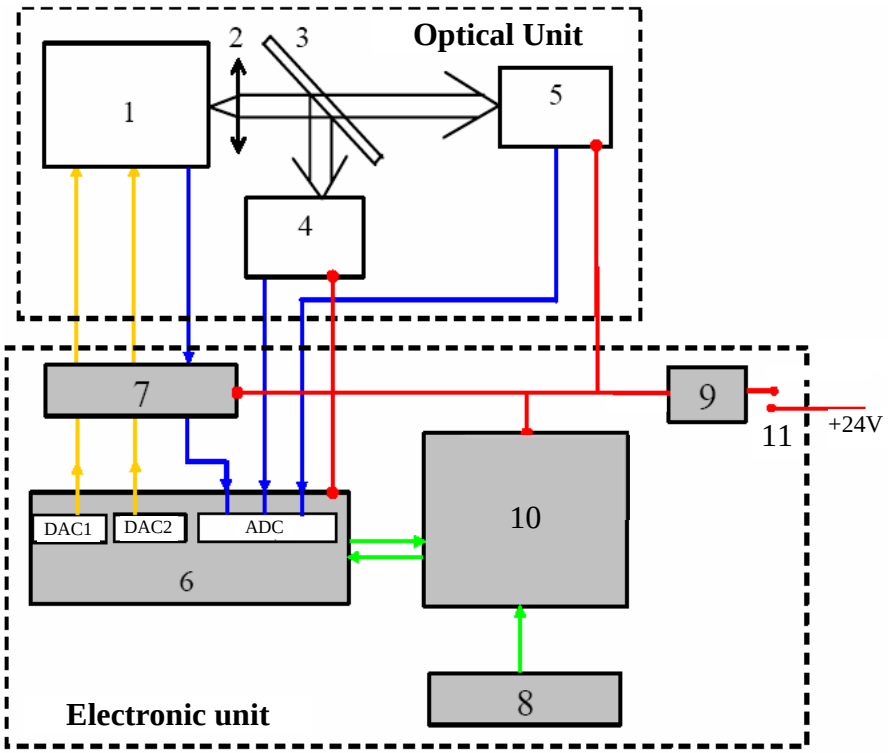
Laser energy is only emitted if the system has power, is switched on, the operator laser switch is in the on position, and the software has been commanded to start running (requires 2 mouse clicks). If any of the switches or the software fails, laser energy cannot be emitted. The software only controls the laser pulsing (on/off) and wavelength (+/- 5 nm). If only the software user interface freezes the laser energy emitted will be same as before and can be stopped with the operator's physical laser switch or stopping the software using the windows operating system. The ALMA G2 also has a JENOPTIK LDM301 Rangefinder that has a class I measuring laser and a class II red aiming laser which is always off for operations (The Rangefinder's nickname is LDM).



ALMA OU Alignment of Optics

The optics in the ALMA OU are carefully aligned during the final step of construction. The reference cell must be replaced on a yearly basis.

12. What are the electronics inside ALMA Gas Detector Section?



Block-scheme of the ALMA G1 Gas Detector

1: Laser unit
2: Objective
3: Beam splitter
4: Reference channel
5: Analytical channel
6: I/O card from NI
7: Analog unit
8: GPS receiver
9: 28 to 12V voltage converter
10: For ALMA G1 – Main Computer, For ALMA G2 – Laptop (NI Card and Laptop communicate over USB)
11: Power switch

13. Is ALMA a Military Tank?

ALMA may look just like a strong metal structure, but is an optically aligned precision instrument and must be treated carefully for reliable operation (Specifically, the computers, monitors, and aviation approved cabling). The optical unit alignment will be damaged if dropped. The optical alignment of the laser, optics, splitter, mirrors, and photodetector can only be done in Switzerland. There is a procedure to try to repair the alignment in the field in case of shock to system.

The ALMA G2 is built with materials mandated to obtain an aviation approval. These materials are not as tough as ordinary since designed to be very light weight, and rigidly and permanently fixed to the helicopter. ALMA G2's ability to be helicopter independent is an immense sales advantage, but in combination with the aviation material results in a system requiring a more refined touch than other field equipment especially when tired and in a hurry to pack at the end of an inspection. Over 90% of reliability issues have been traced back to improper handling.

The laptops are strong, but not tough as rugged/tough laptops as they do not have the performance ALMA requires. The touch pad on some laptop requires a special soft touch to find a reliable spot.

14. Why does the optical unit cable main connector have a cap?

To protect the laser from static electricity damage which significantly degrades the laser power and performance. The cap must immediately be attached when the cable is disconnected from the D-Box.

15. Why does ALMA measure in ppm*m?

ALMA measures the methane for the entire distance that the Laser radiation travels therefore there must be a length unit.

16. Why rangefinder reading cannot be used to convert ppm*m to ppm?

Would create an average concentration over the length of beam and the methane concentration is not consistent. The proportion of the gas cloud to the laser beam length is unknown. As a rough example 23.9ppm*m could have been a cloud 10ppm and a cloud 2.39 meters tall or 100ppm and 0.239 meters. From 75 meters a ppm reading would have been 0.32 which is completely false.

17. Does not require calibration. Why?

The system is initialized with a known reference cell during assembly. The system then calculates the changes over time, pressure, temperature, etc. illustrated by the Reference Cell Absorption value.

The detected level of a pipeline leak depends on hundreds of physical variable between the pipeline and the measuring device. Procedures such as boring a hole near the pipeline to a specific depth then using a specific measuring device at a specific distance are created to control as many of the variables as possible to ensure a consistent reading and classification. The ALMA G2 system detects the natural gas cloud from a leak at proven distances up to 30m / 100ft away from an altitude greater than 150m / 500ft at extremely economic speeds. The detected level therefore depends on a number of additional variables between the pipeline and the measuring area of the system especially the migration of the natural gas in open air.

18. What is the measurement time?

ALMA G2 measure at 0.04 sec (blue line on user interface graphs) and 0.2 sec (red line on user interface graphs) simultaneously. One measurement cycle produces 1 - 0.2 sec and 5 – 0.04 sec measurements. The 0.04 sample rate is faster showing smaller detections, but can show false detections as based on 100 laser pulses. The 0.2 sec sample rate is more reliable and therefore used for alarming, but smaller detections can be lost in the averaging calculation of 500 laser pulses.

Table 1 – ALMA G2 Technical Parameters

Maximum Measurement Distance	150 m
Measurement Time	0.04 sec, 0.2 sec (simultaneously)
Sensitivity for 0.2 sec Measurement Time: from distance 50 m from distance 100 m from distance 150 m	 25 ppm*m 100 ppm*m 225 ppm*m
Maximal Measurable Gas Concentration	20,000 ppm*m
Laser Wavelength	1.65 µm
Laser Power	10 mW
Power Supply	DC 22 - 32 V, 280 W
Total Weight	85 kG
Operating Temperature Range	-10 – +50 °C (Some ALMAs only operate below 35°C)
Laser Beam Diameter: At 50m Altitude At 100m Altitude At 150m Altitude	 0.4m 0.75m 1.1m
Video Cameras	Pilot: Tilted 16° Forward & Aligned with Laser Left and Right for Documenting Pipeline Right-Of-Way
ALMA Camera Resolution • G2/5 (Before Upgrade) • G2 STC • G2/3	 3x Standard Definition: 0.4megapixel @ 10 fps 3x High Definition: 2.0 megapixel @10 fps 3x Ultra+ High Definition: 12.0 megapixel @ 5 fps

19. What is JetRanger Mount?

The JetRanger Mount is additional items attached to the OU to mount it horizontally on the belly of the Bell 206B2 or B3 JetRanger.

The items are:

- Mirror housing with tilted mirror (45°)
  - The rangefinder and cameras are bolted to the sides of the mirror housing
- Cargo Hook Frame (white frame) from Onboard Systems
- Attachment brackets between the OU and Mirror Housing, and Cargo Hook Frame

JetRanger Mount

20. Types of ALMA Inspections

Navigating by GPS Only and Visually Following Pipeline

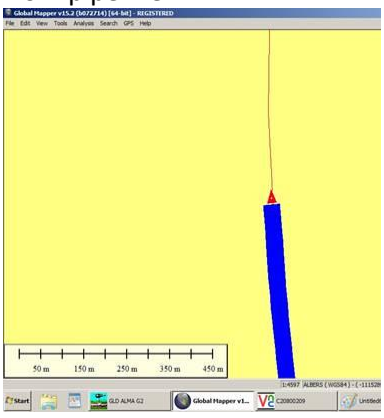
21. What software is used?

ALMA Laptop:

- ALMA runs on Win7.
- The GLD (Gas Leak Detection) on-line software is used for system control, real-time inspection data analysis and monitoring, and data storage.

- Global Mapper: GIS Software. Displays georeferenced information such as GPS position, helicopter tracks, detection locations, pipeline maps, and street maps.

    - Map formats supported can be found at http://www.bluemarblegeo.com/products/global-mapper-formats.php
        - Normally Shape file (.shp) and Google Earth (Kml and Kmz)
    - All maps have a coordinate system (same as the scale of a graph) and a datum (0,0 or starting point of graph). GPS uses a system that covers the whole world. Italy, Switzerland, and many other countries have their own. You need to know this information to open a map correctly in Global Mapper. Global Mapper has hundreds and will ask you to manually select the correct information when opening a map. Theoretically this will happen automatically if there is a projection file (.prj) included with the shape files, but not always. There are also many times that the projection file is incorrect (as seen with the Ohio ALMA inspection) despite the customer having profession staff that runs their geodata software. Also many US pipeline companies use an older datum.
    - Best configuration is a line version of street map in black with pipeline in red.
    - Obtain separate maps files for parallel pipelines so each line can be shown in a different color making navigation easier.
    - For ALMA Inspections by GPS Only use a 40m thick track line to help ensure proper distance from pipeline.



- GPSGate: Splits the GPS signal for use by GLD on-line and Global Mapper by creating 2x virtual com-ports and shows GPS communication status. Red: No communication, Yellow: communication with no GPS position lock, and Green: communication with no GPS position lock.

- DVR Remote video viewing and saving, control, and configure software (see DVR type below).

- VNC/Remote

- Time synchronization: NetTime Server

DVR:

- For KMT or Sintron DVR with LuxRiot:
    1. Video recording software
    2. Time synchronization: NetTime Cleint
    3. Video viewing and saving, control, and configure software: LuxRiot
    4. Free Player: LuxRiot shareware server

    Note: Items 3-4 are not installed on DVR

- For KMT DVR with iGuard (Old and being replaced with LuxRiot):
    1. Video recording software
    2. Time synchronization: NetTime Cleint
    3. Video viewing and saving, control, and configure software: iGuard RemoteView
    4. Free Player: iGuard RemoteView or iGuard Player

    Note: Items 3-4 are not installed on DVR

- For GeoDVR (Special DVR which automatically georeferences the video):
    1. TBD

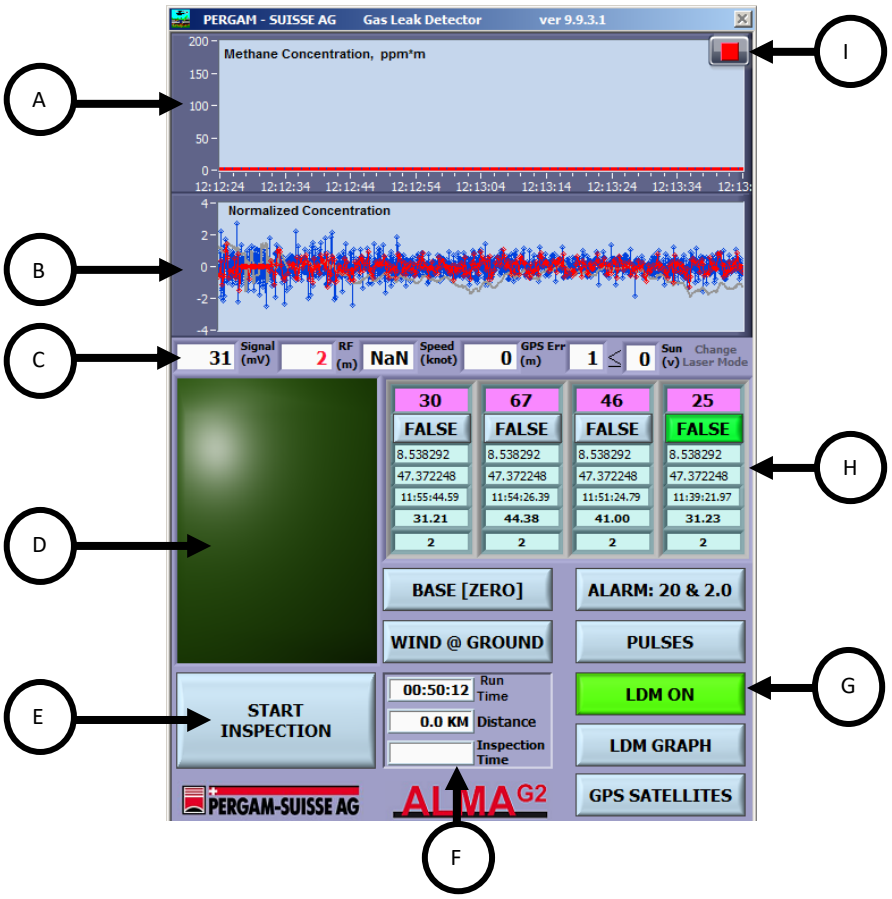
Other:

- The GLD process software is used for off-line review of inspection data and report generation. The software can be installed on any computer.

22. What are the signal and communication paths?

- Methane Detection System:
    - From component to/from NI Card (analog)
    - NI Card over USB to computer (digital)
- GPS: Garmin GPS Device to serial communication then Serial to USB converter then USB on laptop then split by GPS Gate to On-line software and Global Mapper
- Rangefinder (LMD): Serial then Serial to USB converter then USB to laptop
- Time Synchronization: Server to Client over Ethernet
- Laptop to Pilot Monitor: VGA
- Video:
    - Cameras to DVR: IP/Ethernet except G2/5
    - DVR to Laptop: IP/Ethernet
    - Pilot Camera to Pilot Monitor: Analog over coax cable

23. What's on the main screen of the on-line software?



ALMA G2 On-line Software Main Screen

A: Methane Concentration Graph
B: Normalized Concentration Graph
C1: Detection Laser Pulse Signal Strength. Turns red by configurable limit. (Normally 10)
C2: Rangefinder reading. Turns red by configurable high and low limit.
C3: Ground Speed. Turns red by configurable limit. (Normally 65)
C4: GPS Error. Turns red by configurable limit. (Normally 3m)
C5: Sun vs Channel Limit. Turns red when above the channel limit
C6: Change Laser Mode Alarm. Text turns red when Peltier is ≥3.5 prompting to change laser mode.
D: Gas Detection Indicator
E: Start/Stop Inspection Button. Initiates data recording. Flashes Yellow when NOT saving. Shows data file group number when saving.
F: Runtime, Distance, and Inspection Time Indicators
G1: Base Button (Zero's system)
G2: Set ALARM 1 Detection and Cal Screen Button. Disabled when saving
G3: Wind @ Ground Screen Button. Flashes yellow when inspection started and every 20min after use.
G4: Pulse Screen Button
G5: Ranger Finder On/Off Toggle
G6: Range Finder Graph Screen Button
H: Detection Table
H1: Maximum Detection Concentration
H2: False Detection Tag Toggle. Denotes a detection as "False" in the leak file. Green is "False".
H3: Detection Longitude
H4: Detection Latitude
H5: Detection Time
H6: Detection Signal Strength
H7: Detection Range Finder Reading
I: Exit Button. Disabled when saving

24. What does a gas detection look like?

ALMA G2 On-line Software Main Screen with Leak Detection Spike

25. Why are there two graphs?

The two graphs help distinguish between noise and a gas detection. Upper graph is the signal with noise subtracted. Lower graph is the signal to noise ratio. A spike in only one graph is noise. Having the 2 graphs gives a second perspective on the data.

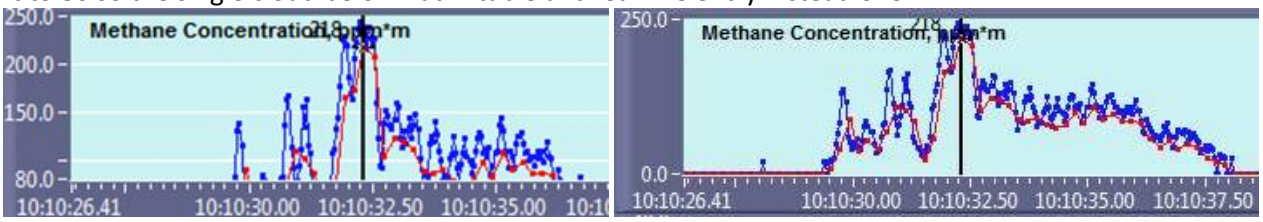
26. How is the scale of the graphs changed?

Click on the axis min or max and enter a new value, or use zoom controls. Right clicking on the screen gives other options.

27. What are ALARM 1 and ALARM 2?

Alarm 1 controls when the detection indicator turns red, a column is added to detection table, and detection data added to leak file. Control is on main screen. Set to above noise or to desired level based on customer biased on customers per flight/ daily report needs.

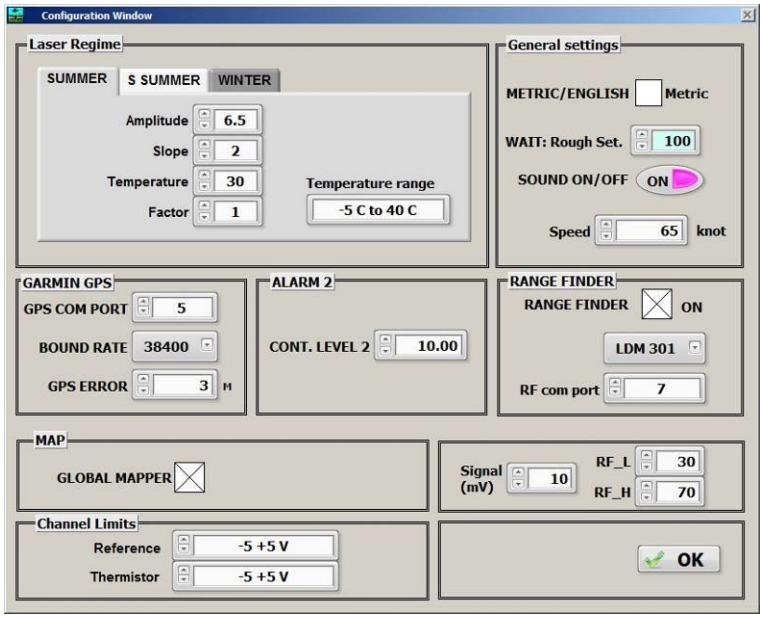
The system automatically summarizes a cloud into a single table and leak file entry. Automatic cloud grouping combines any ALARM 1 indication occurring within 3 second of another. Example: ALARM 1 was sent to 80 so the single cloud below had 1 table and leak file entry instead of 3.



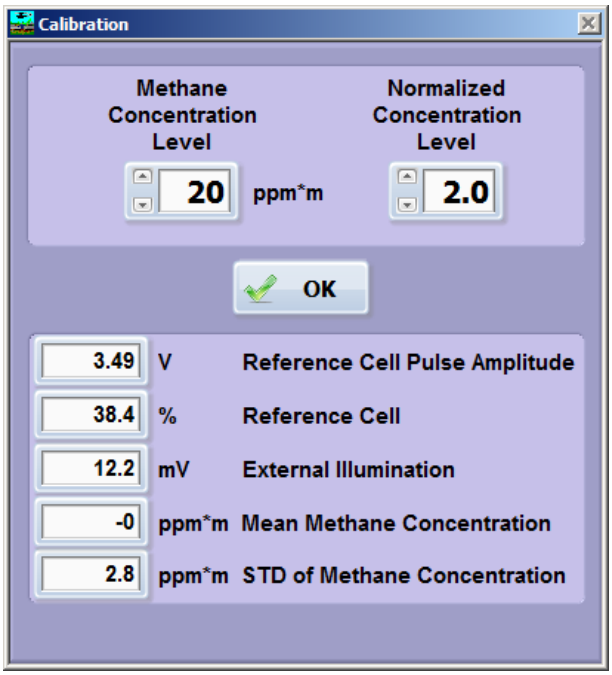
The "Norm Level" level filters out all gas detections below value particularly spikes in "Methane Concentration" graph.

Alarm 2 controls when advanced data (pulse data) for post processing is saved. Control is on config screen. Set to 10.

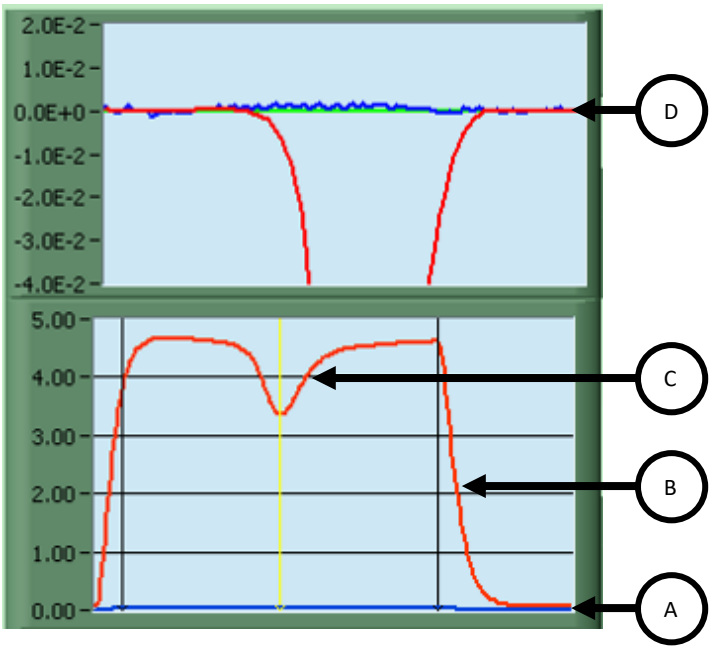
28. Configuration (Config) Screen?



29. ALARM 1 and Cal (Calculation) screen?



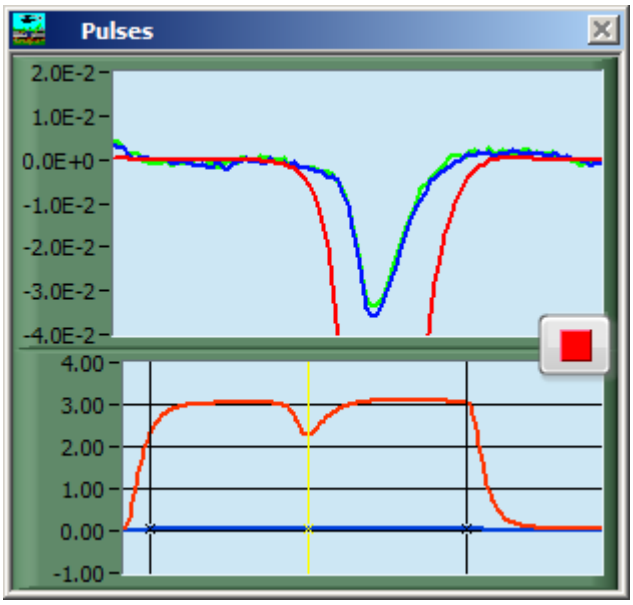
30. What does the Laser pulse look like?



ALMA Pulse Screen

A: Analytical Channel Signal (Blue Line)
B: Reference Channel Signal (Red Line)
C: Methane Absorption in Reference Channel Signal
D: Analytical Channel Signal Superimposed on Reference Channel Signal
Green Line is Analytical Channel Signal from Last Leak detection

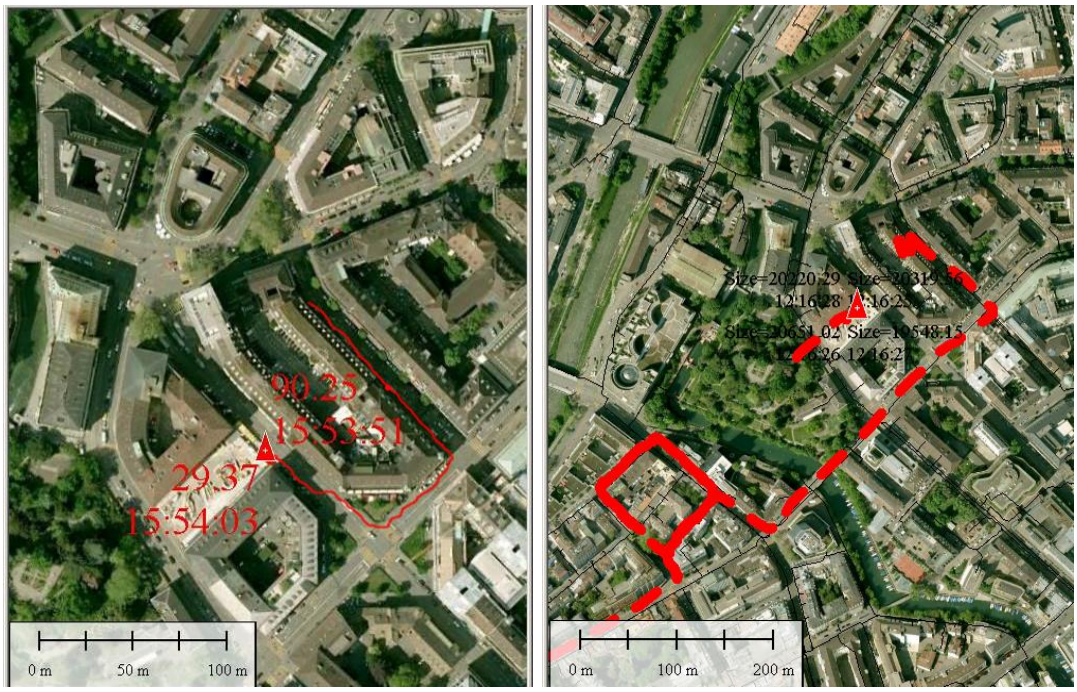
31. What does the Laser pulse look like during a massive gas detection?



ALMA Pulse Screen Showing Massive Leak Detection

32. Real time detection in Global Mapper?

The Gas Detection Position with Maximum Concentration and Time Stamp of an Alarm 1 is displayed in real-time in Global Mapper when enabled via the configuration screen. Information is display instantly after gas detection is complete in order to calculate position of maximum concentration.

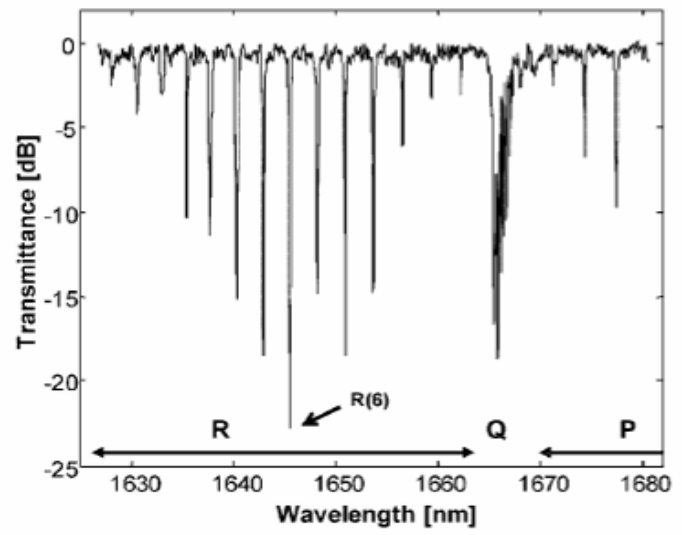


Global Mapper Screen With Vehicle Position, Vehicle Track,
And Gas Detection (Position Dot, Max Concentration, and Time)

If ALARM 1 level is in the noise range (too low) Global Mapper gets overloaded with data and the background turns black. Need to change background and reconfigure.

33. What are "r-lines"?

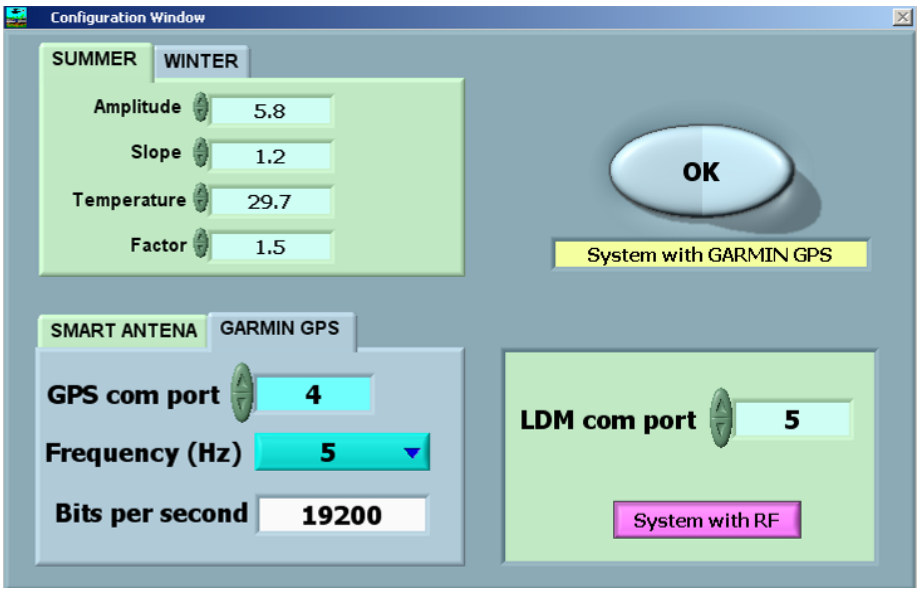
"R-lines" is the name for the first light absorption band or group for methane gas. The ALMA emits a rainbow of infrared with one of these lines in the middle.



Methane "R", "Q", and "P" Absorption Lines

34. What are the Laser parameters for?

The Laser parameters are used by the system to tune the Laser's output to the correct absorption line during equipment start-up and operation. Each Laser has a unique set. Use of Winter, Summer, and Super Summer parameters (laser mode) depends on the ambient temperature. The Winter, Summer, and Super Summer absorption lines are not the same for different Lasers. Some Lasers do not have Super Summer parameters.



ALMA G2 On-line Software Configuration Window

35. Temperature Range and Temperature Mode Selection, and "Change Laser Mode" alarm

Temperature range is -25 and +15C from laser setpoint for the system only has limited capacity to heat or cool the laser via Peltier. The temperature mode is selected by the expected temperature the laser will experience during the inspection. Remember that the metal around the laser will hold or buffer the laser temperature delaying a change. The "Change Laser Mode" alarm test turns red when the capacity is nearing limit. ALMA Inspection can continue, but system noise will increase.

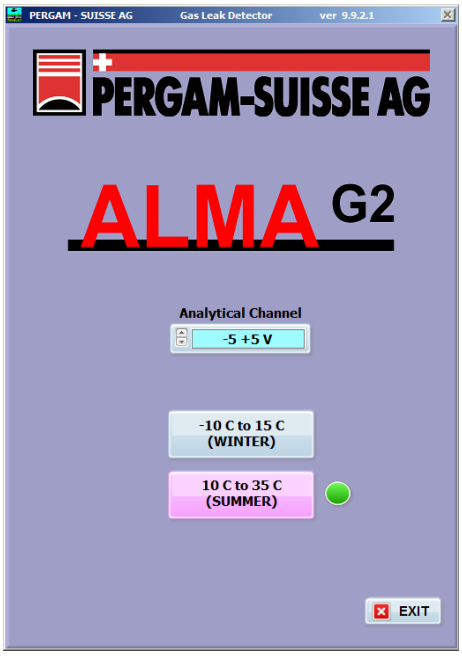
36. What should the pulse signal strength be?

Greater than 9 mV is preferred. Greater than 5 mV is OK. It is possible to have detections at 1 mV, but the potential for false gas detections is higher. The value depends on the Laser beam length and reflectivity of the ground target. If it is too low then fly lower. Expect the reflectivity to be low when over corn fields, brush, and other thick vegetation.

If the signal goes too far below 1 then a NaN will appear, ALMA is no longer able to inspect for methane, a "chirp" audible alarm will sound once, the data stream in the lower graph will stop, and "Pipeline Not Inspected - Signal" will be logged in note file.

37. What are the channel limits?

Channel limits are a configuration setting for what voltage range (scale) should the NI card convert the analog signals to digital. Lower settings have less digital noise and better resolution. The limits for the analytical channel must be changed based on sunlight conditions (10 V for very bright, 5 V for normal, 2 V for very overcast) at start up for the entire flight. On-line software must be restarted to change. Settings used need to be documented in log.



Start Screen with
Analytical Channel Limit control

If the analytical channel exceeds its limit due to addition light (sunny day) then ALMA is no longer able to inspect for methane and the following items occur:

1. "Sun" value on main screen turns red
2. A "chirp" audible alarm will sound once
3. "Pipeline Not Inspected - Channel Limit" will be logged in note file.
4. There is no data available to be displayed on the main screen two graphs (No new data is added to graphs) or for the blue line in pulse graph.

38. What is the GLD on-line password for?

Access to the configuration window and filter information. Password: SadEovLSD

39. What is the difference between a gas detection and a leak?

A gas detection is only when methane gas is found by the equipment independent of its source. A leak is when the source is most probably from the pipeline.

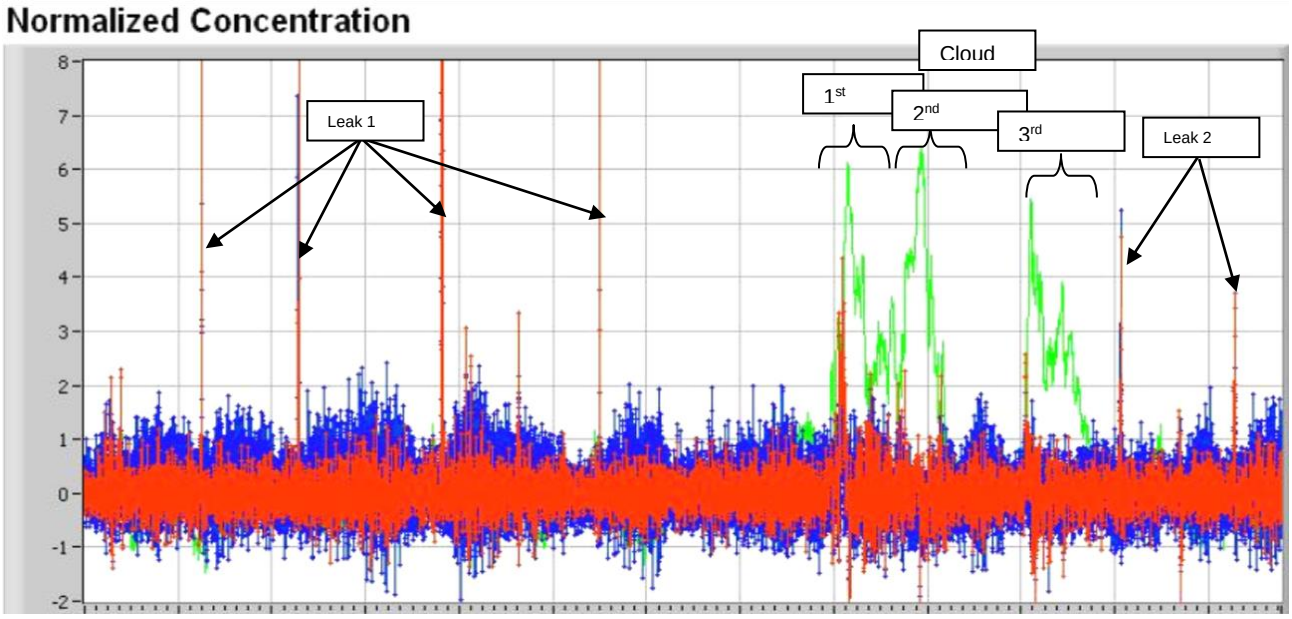
40. How to determine the source of the methane?

ALMA can detect methane gas coming from other sources than the pipeline such as animals, farms, cars/trucks, etc…

To determine the source we look at the size and concentration of the gas cloud detected, and the video. The size is based on the how many continually elevated concentration samples make up the detection. If the size is small or tiny, concentration is low and the video shows other possible sources of gas then the probably that the gas detection is a leak in the pipeline is low.

41. How does the system compensate for atmospheric methane?

ALMA automatically compensates for atmospheric methane using a range finder and an algorithm. The system continually calculates then disregards the atmospheric methane. The system can be manually compensated by having the pilot point the Laser upwind of the pipeline and clicking “Base” button. Also the ALMA measures methane to ground level (along the length of the Laser beam) where the concentration of the gas cloud is higher making the difference between atmospheric methane and the gas cloud more dramatic. This functionality will also filter out the majority of bio methane gas sources such as from fields or farms depending on the concentration of the gas cloud. Information about these low concentration large gas clouds is available per the green/grey line in normalized concentration graph.



42. What is the ROW

Right-Of-Way. Area above of buried pipelines or below above ground pipelines 3-30m / 10-100feet on either side which is controlled by the pipeline owner. Normally 100 feet during construction.

43. What does the video recording system consist of?

- Digital Video Recorder (DVR)
  - Black - KMT
  - Grey - Sintron
- Pilot Monitor
- Pilot Camera
- Left &Right Cameras
- Time server running on laptop

DVR:

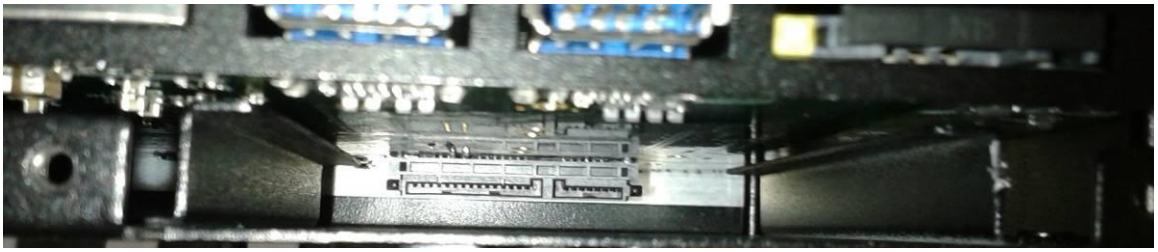
IMPORTANT: Install Solid State Drives (SSDs) Carefully to Ensure Detection By DVR.

The professional quality SSDs used in the ALMA are thinner than hard disks so extra care must be taken when installing them to ensure they align with the DVR connector. If the SSD is not properly in the connector then the DVR will not detect it and there will not be enough storage for the inspection video. SSDs have no moving parts so will not fail often mid inspection like the previous hard disks. Installation in the Black KMT DVRs is similar to before due to the mounting bracket design. The Grey Sintron is more difficult and instructions are below.

- SSDs

- Hard Disk

- Connector in DVR



Note: Off-the-shelf spacers were tested. One broke and the other melted. A solution is still under investigation

SSD INSTALLATION (Practice a few times when ALMA is on A/C power)

1. Ensure the SSD is parallel to top of mounting bracket then check mounting screws are tight.

2. Pushing down on the thumb screws so the bottom of the mounting bracket is flat on the plate, slide the SSD into the slot until mounting bracket is flush with DVR face.

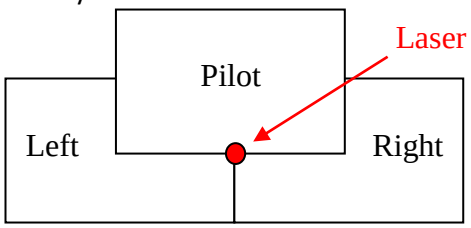
3. Use a screw driver to secure the SSD in place.

4. Start system and check that DVR Windows has detected SSD (via My Computer).

CAMERAS:

The Pilot Camera depicts where the laser is pointed and is connected to the DVR and Pilot Monitor. The Left and Right Cameras depict the area around the detection and pipeline, and are connected to the DVR. The DVR records the images from the cameras.

Camera Layout:



Frame Rate:

- ALMA G2 STC: Normally 10fps (System must be started in correct order to achieve)
- ALMA G2/3: ≥5fps.
- ALMA G2/5: Currently same as G2 STC. Future with GeoDVR: TBD

Left and Right Resolution a 75m / 250ft:

- ALMA G2 STC: 2mp with each pixel covers 3.5x 3.6cm.
- ALMA G2/3: 12mp with each pixel covers 1.5 x 1.6cm
- ALMA G2/5: Currently 0.7mp. Future with GeoDVR: TBD

Left and Right Coverage:

Each camera has 40° horizontal view due to limits of space in camera housing (42°-45° used for overlap). From 60m altitude both cameras together are 100m wide resulting in 30+m / 100+ft on either side of pipeline (Max ROW size). At 30m (Normal Minimum Inspection Altitude) are 50m wide and 18.75m tall. 65 knots is 33m/s so at 7.5fps there is a new frame every 4.4m. Goal is to picture a location 4 times requiring minimum 4 frames per second.

Pilot Coverage:

- ALMA G2 STC: Horizontal view is 40°.
- ALMA G2/3: Horizontal view is 70°. At 30m it is 30m tall (52.5°) and 40m wide

Focus and Iris Adjustment:

It is the responsibility of the ALMA operator to adjust the focus and iris for expected flight altitude and light conditions for the inspection prior to installation on the helicopter.

Note: ALMA G2/3 pilot camera and ALMA G2/5 with iGuard and PAL cameras to not need adjustment. The future GeoDVR version of the ALMA G2/5 may require adjustment.

44. What is the height alarm for?

To help the operator ensure the full ROW is documented via the camera and video system based on customer requirements. The RF value on the main screen turns red when below the RF_L value and above the RF_H value on configuration screen. If there are no customer requirements for documenting ROW then use 30 for RF_L and 70 for RF_H as this is normal range for a high quality inspection.

45. Why is there a time sever running on the laptop?

The ALMA G2 is actually 2 systems (a methane gas detector and a video recording system) linked by time stamp. The methane gas detector uses the laptop time directly. The DVR synchronizes with the laptop time via the time server. It is important to check that this system is working before the inspection starts by comparing the laptop time to the video time.

46. What is the role of the operator?

The operator monitors the data provided by the system to confirm gas detections, helps the pilot with navigating along the pipeline, records wind direction periodically, and determines if an area needs further inspection. The operator must command the methane gas detector software to start and stop saving data as the software does not automatically start saving as 99% of time there is a ferry distance to the pipeline. The operator must zero or base the system via the “base” button when the average normalized concentration goes above +/- 3 or per preference. Remember laser must be upwind of gas sources before using “base” button. The Mean Methane Concentration and STD of Methane Concentration with lower with single use of “base” button, but reaction is delayed due to nature of calculation therefore multiple use of “base” button is not required.

47. What is the role of the pilot?

To safely manipulate the helicopter’s position and attitude so the Laser ground spot passes downwind of the pipeline at an acceptable distance. The pilot monitor and GPS information aid the pilot in aiming the Laser. We have found this method superior to any other control solution as the pilot can instantly change the laser position to compensate for different terrain and weather conditions. It is advisable that pilot practice aiming the Laser before starting the inspection (example: follow a road).

48. What is workload in aviation industry and why is this to be controlled?

How many overlapping things a person must perform, pay attention to, or monitor. Controlling or reducing workload results in the pilot or operator having more capacity to perform remaining tasks with higher quality. This is one of the design principles behind the latest ALMA improvements.

49. Observation Log?

The ALMA has an observation log for recording items observed during the flight. Press the “space” bar to open a log, but wait until helicopter is right above spot to ensure automatically saved GPS location is correct. Some customers do not want any observations, some all plus others, and some only part of the list.

Note: ROW is 10-100feet either side of pipeline. Exact size must be obtained from Gas Company

1.1 Dangerous Hazards →Log & Report Immediately

- 1.1.1 Excavation Over or Near Pipeline: Digging or Deep Plowing
- 1.1.2 Fire Near or In ROW
- 1.1.3 Downed Powerline Near or In ROW

1.2 Observations

- 1.2.1 ROW Encroachment: Activity on the ROW from other than Gas Company. Example - Illegal Tap, Unusual Off Road Vehicle Activity, etc…
- 1.2.2 Construction In or Near ROW
- 1.2.3 ROW Excess Vegetation (Use carefully as thick vegetation can block ALMA laser)
- 1.2.4 ROW Flooded
- 1.2.5 Pipeline Exposed
- 1.2.6 Pipeline Missing Support
- 1.2.7 Pipeline Corrosion
- 1.2.8 Pipeline Sign or Marker Missing or Damaged
- 1.2.9 Facility Needs Repair Corrosion, or Unsecure
- 1.2.10 Facility Excess Vegetation
- 1.2.11 Dead Vegetation or Animals / Colored Snow (Indications of gas leak)

1.3 Inspection Notes

- 1.3.1 Obstruction Blocking Inspection: Example - Tall Antenna, Airport prohibiting fly-over
- 1.3.2 Pipeline Map Incorrect
- 1.3.3 Gas Source Not Pipeline
- 1.3.4 False Detection
- 1.3.5 Repeat Detection

50. Why use ear bud headphones with ALMA?

The operator is responsible for multiple task at same time. Using small ear bud headphones that fit under the helicopter headset or helmet allows the operator to spend more time looking outside of the helicopter to perform the pipeline observation work as the system will notify when there is an Alarm 1. Plus is more comfortable. A quick scan of the laptop couple times a minute is still required to ensure ALMA and the camera system are operating normally. Do not connect the laptop to helicopter audio system as normally makes a ground loop causing damage and higher system noise.

51. What is an hour in 50 or 100 hour maintenance?

An hour is a flight hour with the ALMA installed on the helicopter operating or not.

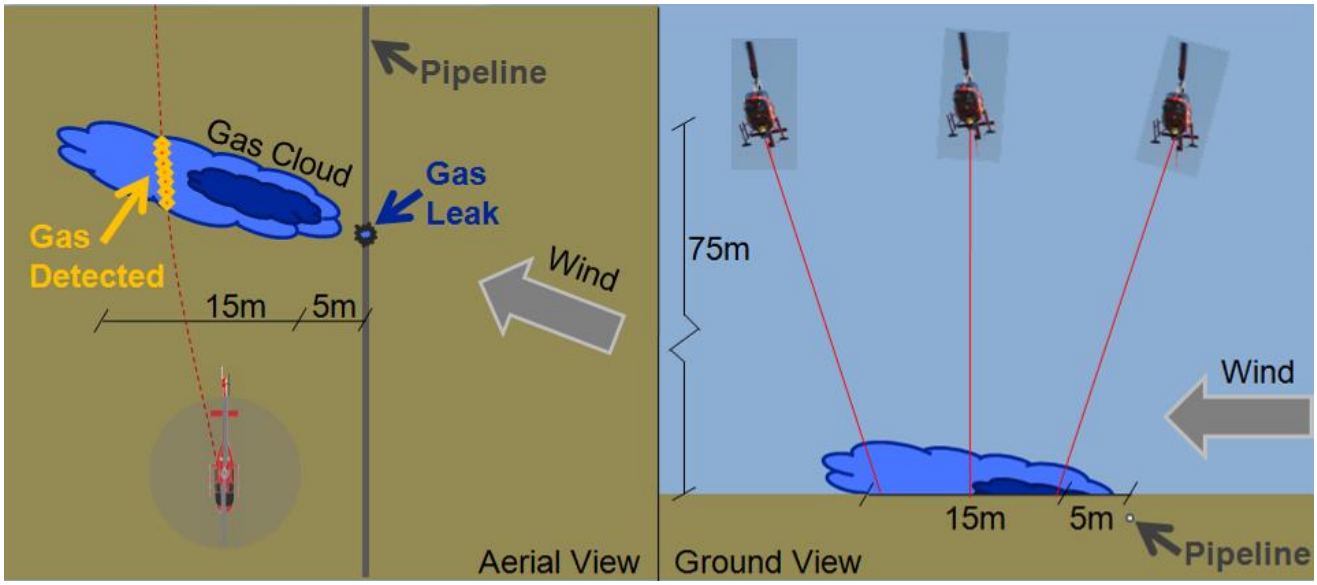
Maintenance must be performed every 100 hours or before otherwise it is illegal for the helicopter to fly with the ALMA installed. Have the maintenance work performed before installing the ALMA when the next inspection is either very long or the ALMA will go over the 100 hours. For example: ALMA has 12 hours since last 100 hour maintenance, but the inspection will be 90 hours including ferry time.

52. Navigating the pipeline

Normally a combination of GPS waypoint for the pipeline and pipeline markers are used to navigate the pipeline.

53. How does one fly with the ALMA to ensure a good inspection?

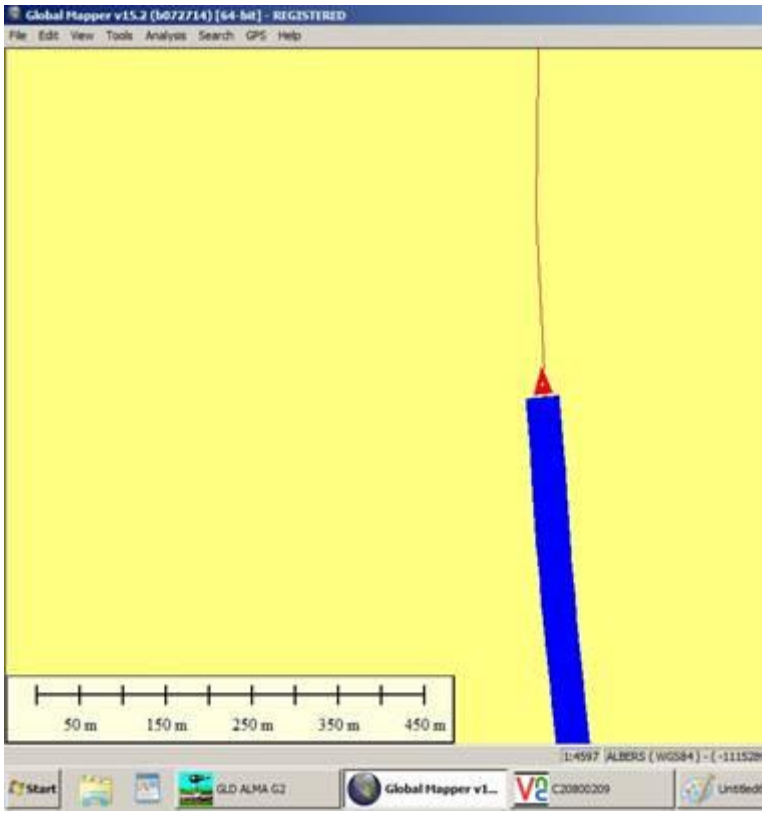
- The ALMA equipment detects the gas cloud coming from the leak in the pipeline not the leak itself.
- ALMA must have "line of sight" with pipeline.
- ALMA's Laser must pass downwind of the pipeline to detect the gas cloud.



- For good balance of economy and ability to detect gas leaks the normal flight profile is:
  - ALMA G2: 250 feet AGL or 75m @ 65 knots IAS (Operate in safe area of HV diagram)

  Note: Flying slower improves the equipments ability to detect smaller gas clouds.
  Flying lower improves the equipment's sensitivity.
  Higher speeds and altitudes make aiming the Laser in the correct area more difficult
- Weather
  - Wind: ALMA has the proven ability to detect gas leaks at winds up to 25 knots. Best results are when there is some wind to make the gas cloud larger.
  - Water and Ice: ALMA does not operate over a mirrored surface such as water or ice because too much of the Laser light is reflected away from the system. The two graphs on the on-line software will be missing data when the laser reflecting of water and ice.
  - Rain and fog: ALMA can fly in light rain, but must be protected from other rain conditions. Wet ground can temporarily seal leaks resulting in a poor inspection. Rain, fog, and significantly wet ground may require a lower inspection altitude to obtain an acceptable pulse signal strength.
  - Snow: ALMA can operate over snow. Usually the altitude has to be decreased by 50% to obtain an acceptable pulse signal strength.
    Note: Water, Ice, Snow and frozen ground makes the leak gas cloud location less predictable.
  - Sunlight roughly overhead can decrease the sensitivity of the equipment.
  - Best conditions for inspection: Overcast; no snow, ice, or water; and light crosswind
- Gas detections should be confirmed with additional fly-over depending on customer's preference as requires additional flight time resulting in added cost.

54. Why use 40m thick track line?



55. When is methane explosive

Natural Gas has 5% LEL and 15% HEL.

56. Detection size and relation to leak size?

History: Customers do not know how to interpret ALMA G2 inspection results as there is not a repeatable strong correlation between results and actual leak size. To meet the demand a statistical analysis created a classification system method, but has a large error rate due to the number of uncontrolled variables.

Current: Some customers still want the classification system, but others do not. The ALMA Operator must determine customer requirements. Pergam recommends that every detection results be verified on the ground to determine actual hazard.

To be included in reports:

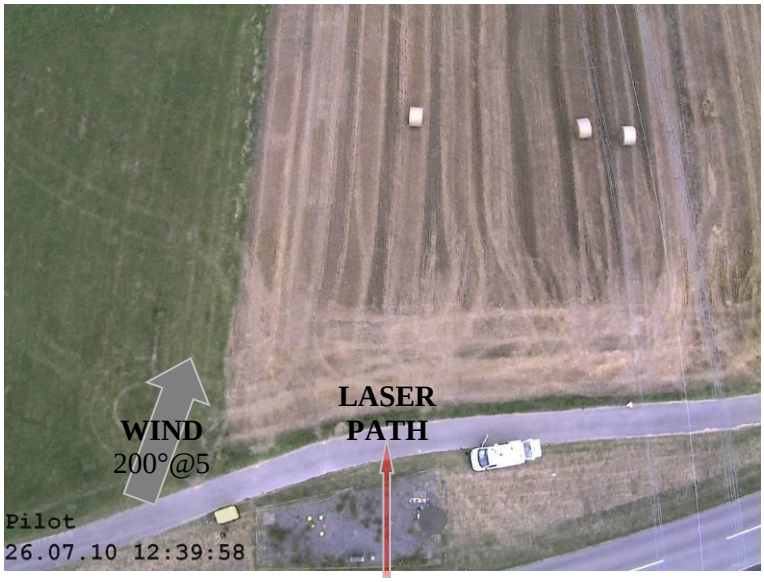
> All detections made by the ALMA G2 system are detailed in this report. The detection with concentrations around 50 ppm*m and lower have a low probability of being a leak in the natural gas pipeline. However it is recommended to check all detections listed in this report.

Future: Cloud Sectional Area (CSA) or 3D Google maps

57. Why record wind information?

Wind information is critical to performing a quality inspection.

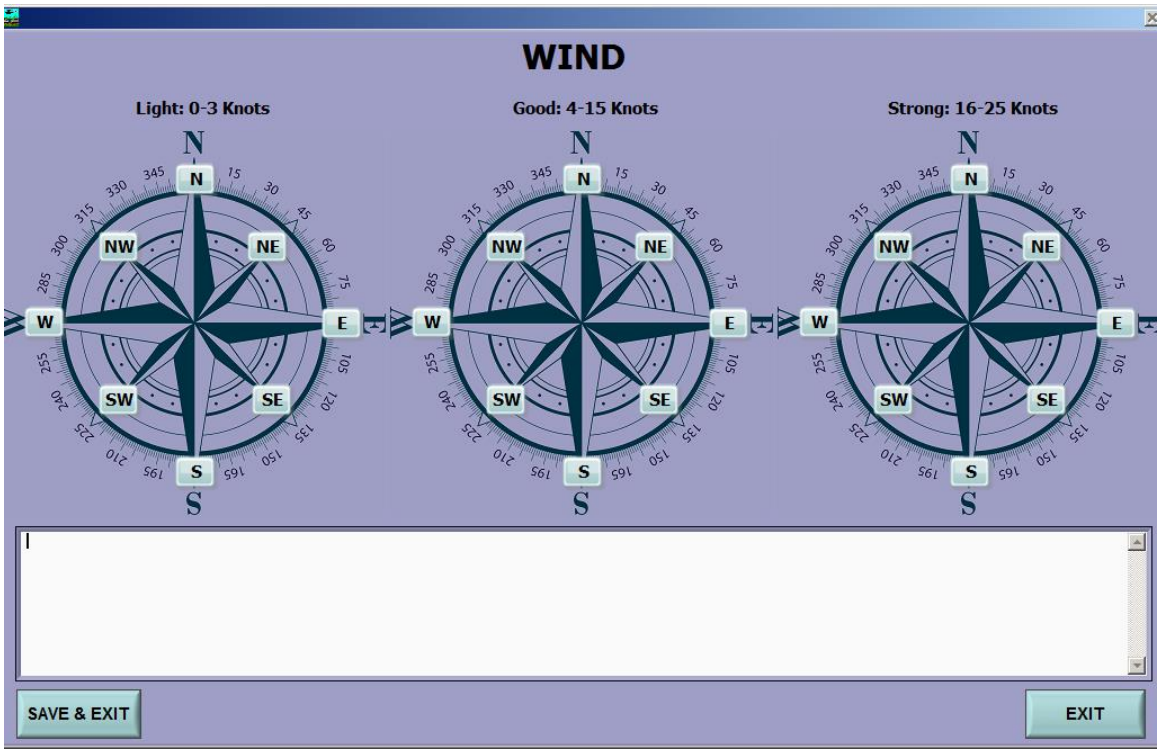
Insurance: To have detail field records for customers to use during post analysis of the helicopter track when ensure inspection performed correctly. Also to have available during post analysis and customer complaints for not finding leaks. Plus the requests are a constant reminder for the pilot to point the laser correctly



58. Is the wind the same direction at ground level as at 50m AGL?

59. Wind log?

Clicking on the WIND @ Ground button opens the wind log screen with 3x sets of buttons for North, Northeast, East, Southest, South, Southwest, West, and Northwest in shape like a map compass. 1 set is for "Light: 0-3 Knots", 1 for "Good: 4-15 Knots", and 1 for "Strong: 16-25 Knots". Click on a button enters for example "Wind: North & Good" with time and GPS in wind file ex "Wind_DDMMYY_000.txt"



60. Why can use only SD cards with the ALMA computers and not USB sticks or connect a mobile phone?

USB sticks and connecting mobile phones add drivers that reduce reliability of system's computer. USB stick used for software restore was carefully selected, tested, and controlled.

61. How to use master switch status light dimmer and push to test?

Dimmer 100% Open

Dimmer 100% Closed (Twist)

Push to Test

62. How to make the report?

1. Analysis of the data using Process Software
    a. Good to have wind information for flights
2. Saving images from videos based on leak detection time from analysis results list.
    a. All pictures for 1 report must be in the same folder.
3. Uses Process Software to create report

Note: A semi-automatic process is available.

63. Daily reports?

Many customers want a daily report. Currently there are several ways to produce the report based on customer expectations.
Full Results: Can only be obtained after analysis with the process software which requires 1-2 hour of time to be schedule instead of inspection resulting in higher costs of more helicopter and pilot time.

Larger Results: A report with detections above 100, 80 or even 50 ppm*m depending on system noise can be made by using the leak files filled by ALARM 1. This process can also be used to make per flight inspection reports. One can easily delete the detections denoted as “False” via the main screen “False Detection Tag” toggle.

The whole process hopefully will be automated as part of the Report 2.0 project.

64. What to give customers?

1. Leak Detection Report in PDF
2. Data still in folders with trak file exported to .txt
3. Video data
4. Video viewer software depending on DVR used
5. Video viewing instructions depending on DVR used in pdf format. Check that they are the latest version before using/sending.
6. Instructions to Obtain the GPS Location of a Video Frame in pdf format. Check that they are the latest version before using/sending.