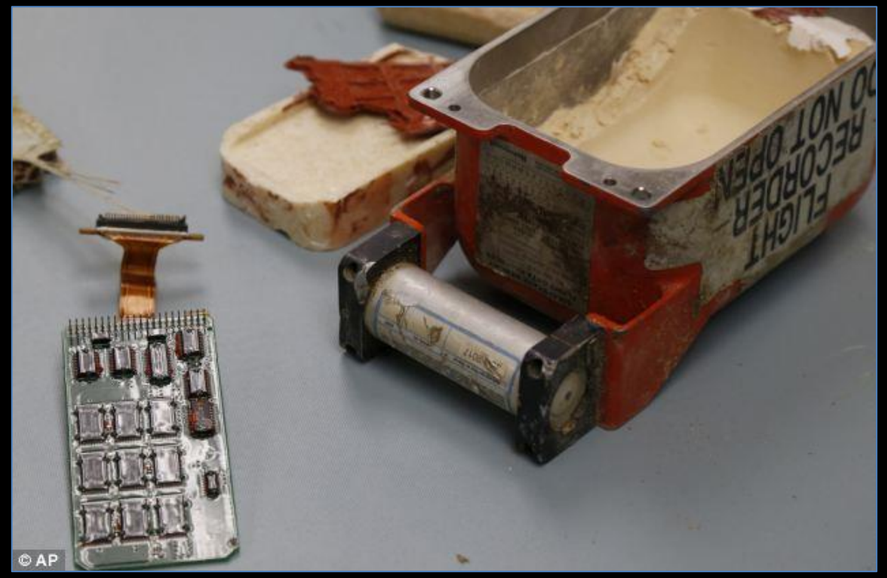
lumina|mars Info Pack

FDR/CVR Memory Access Retrieval System

MARS (FDR/CVR Memory Access Retrieval System) is designed solely for accident investigation authorities. When solid state flight recorders were introduced in the early 1990's, experienced flight recorder experts were concerned about what could happen during the replay process 'when things could go wrong'. Former digital magnetic tape recording technology often required highly specialized replay techniques that went well beyond the standard replay equipment offered by the recorder manufacturers. With the introduction of solid state, the international flight recorder investigative community decided that the default replay method would be to simply substitute the memory from a severely crash-damaged recorder into an identical working recorder. This became known as the 'Golden Chassis' method. It was left up to investigators to engineer specialized techniques as they gained experience with solid state recorders, similar to what was done for digital magnetic tape recorders.

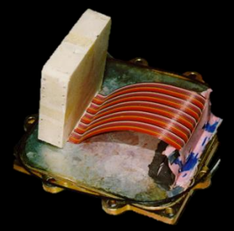
MARS does away with the need for authorities to maintain a large inventory of working solid state flight recorders to serve as a Golden Chassis and does not rely on the firmware within the Golden Chassis to recover the memory contents. The memory chips are directly interfaced to the **MARS** unit offering Investigators the best opportunity to recover the full contents especially when things don't always work as planned with the 'normal' replay methods.



The Aviation Investigation Bureau of Saudi Arabia sponsored the initial MARS development as part of their lab upgrade to handle crash-damaged flight recorders.

Golden Chassis Default Method

Crash memory unit removed from accident SSFDR



Re-install accident memory into working 'golden chassis' bench unit

Standard 'airline' replay through recorder firmware front connector

- In 1990 when solid state memory was being contemplated to replace digital magnetic tape, in flight recorders, it was decided (at EUROCAE) that it was not feasible to require the recorder OEM to develop memory board/chip level readout. Investigators would have to first gain experience with the new technology to discover what challenges they would face when things don't work as planned which is sometimes the case in accident investigations. As was done with digital magnetic tape recorders, it was agreed that the authorities would develop their own specialized techniques over time.

- Initially at EUROCAE, investigators wanted to dictate the memory structure to OEM's to ensure they would understand the underlying format of the data. Rather than restrict design, EUROCAE ED112 contains wording specific to solid sate recordings which requires manufacturers to provide documentation to enable an authority to 'manufacture any special tools' needed to replay recorders. The intent of this language was to ensure manufacturers would appreciate the future need for the investigation community to go above and beyond the normal replay method of the default Golden Chassis method.

Problems with the Golden Chassis Default Method

- The Golden Chassis method assumes the normal replay works properly; there is no ability to cater to unforeseen problems; The replay is ALL OR NOTHING!
- It requires the recorder firmware, EEPROM which stores memory management information and the memory chips to all work properly. There have already been cases where the EEPROM 'wore out' and the Golden Chassis did not work because the standard replay requires the EEPROM information to, among other things, know where to start the replay from the memory (the EEPROM documents where the recording stopped in the memory) .
- There is no transparency into the replay process to produce the data or audio and no ability to intervene in the process to address problems that might occur along the way (such as power interruptions, sync losses, partial chip loss, etc).
- The Golden Chassis will not work if the CVR bulk erase was activated (the bulk erase status is typically stored in the EEPROM).
- The surrogate recorder Golden Chassis (A.K.A. bench units) and/or download system for many older model first generation solid state flight recorders are no longer in manufacture and/or are no longer supported by the OEM.
- Unlike digital magnetic tape recorders which had relatively few models, solid state recorders are rapidly evolving in parallel with chip technology changes, resulting in many recorder models which requires numerous bench units and associated maintenance of the matching firmware.

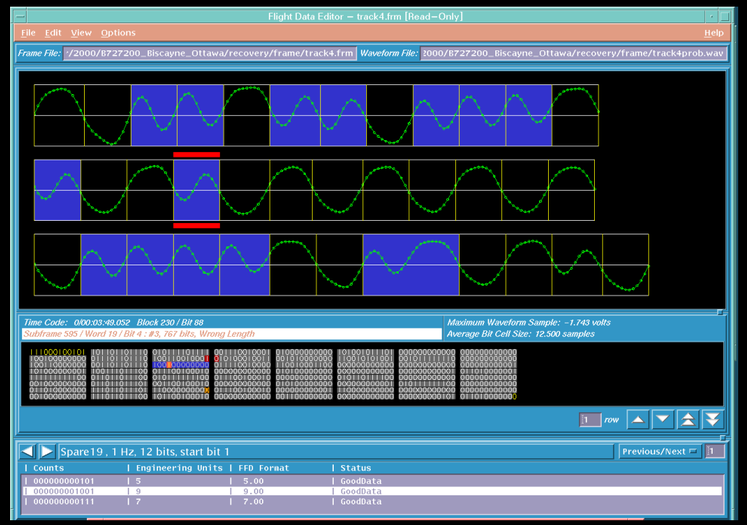
There are 40+ solid state recorders currently installed in aircraft each with various subtypes with multiple memory/firmware variances

Problems with the Golden Chassis Default Method

Over-reliance on the OEM represents long term risk to investigators if the OEM is not in business or discontinues a model or the primary OEM 'expert' who designed the recorder may is longer be available; expertise is often 'one deep' even at the larger OEMs.

As one of many examples, in a 1997 accident, five seconds of data was missing from the solid state recorder normal damaged replay process. The five seconds were eventually recovered by the investigative authority's subject matter expert working closely with the OEM expert who designed the recorder and memory structure. Without the OEM SME's availability, it is questionable today that authorities would be able to recover missing seconds like this example. While these problems are rare, solid state technology poses a real threat especially with older recorders where the expertise required for specialized playback may no longer be available.

1997 accident in which five seconds of missing data were missing using the normal replay method



Screen shot of software to replay digital magnetic tape recorders developed by Plane Sciences experts when formerly employed with the TSB/Canada

With former digital magnetic tape technology, investigators developed extremely elaborate techniques to recover data well beyond what the OEM's standard replay. The waveform from the recording was digitized and decoded with specialized software developed by the authorities. A "Wave/Bit" editor was used to insert, delete and toggle bits, with the underlying waveform and converted engineering units present. **MARS** is the 'solid state' equivalent to what was done for digital magnetic tape recorders.

How MARS Works

The AIB of Saudi Arabia requested Plane Sciences to upgrade their flight recorder lab to handle crash-damaged flight recorders. In 1990 when solid state recorders were introduced, there were only a handful of authorities with flight recorder playback labs. These few labs slowly acquired bench units as they were introduced to the market. An authority wishing to develop a lab today would have to purchase the entire inventory of 40+ recorders all in one shot, that the established labs acquired over many years. Given there were already albeit rare cases where the Golden Chassis method did not work; given the large number of recorders on the market; given that many of the older models are no longer in manufacturer; it simply no longer makes sense for a new lab to purchase and maintain a large inventory of flight recorder bench units to mostly sit on a shelf and collect dust for the rare, literally 10 minutes, you may need to use it to substitute crash-damaged memory into.

MARS ***reads the memory board directly*** without the need for a Golden Chassis or OEM decompression software. By having control of the entire process from start to finish, investigators have the ability to intervene when things don't work according to plan. Note that **MARS** also has the capability of reading undamaged recorders where the crash-survivable memory unit can be removed from the chassis, to expose the memory board's cable and connector.

MARS 1st prototype downloading at the CSMU
(Crash Survivable Memory Unit) level (left) or at the memory board level (right

MARS Project Steering Committee

The MARS Prototype shown in the hands of the Steering Committee Chairman, was used for the first time in an actual case in November 2017 to recover data from a solid state Cockpit Voice Recorder where the Golden Chassis method did not work.

From left to right: Plane Sciences SME Victor Lynch-Staunton, Saudi AIB recorder specialist Ghazi Al Harbi, Saudi AIB MARS SC Chair Ismail Kashkash, TSB Director Leo Donati (SC member), NRC Director Viresh Wickramasinghe (SC Member), Plane Sciences Project Lead Bob Hoyle, Plane Sciences CEO Mike Poole (absent Robin Bassom, Plane Sciences SME Advisor)

MARS Installations

MARS was installed at AIB Saudi Arabia and AAIB Malaysia in 2017, Nigeria in 2018, Papua New Guinea in 2019, and China and Russia in 2020. The 1st production release of MARS is a rack mounted unit within an optional Electro-Static Discharge (ESD) work bench.

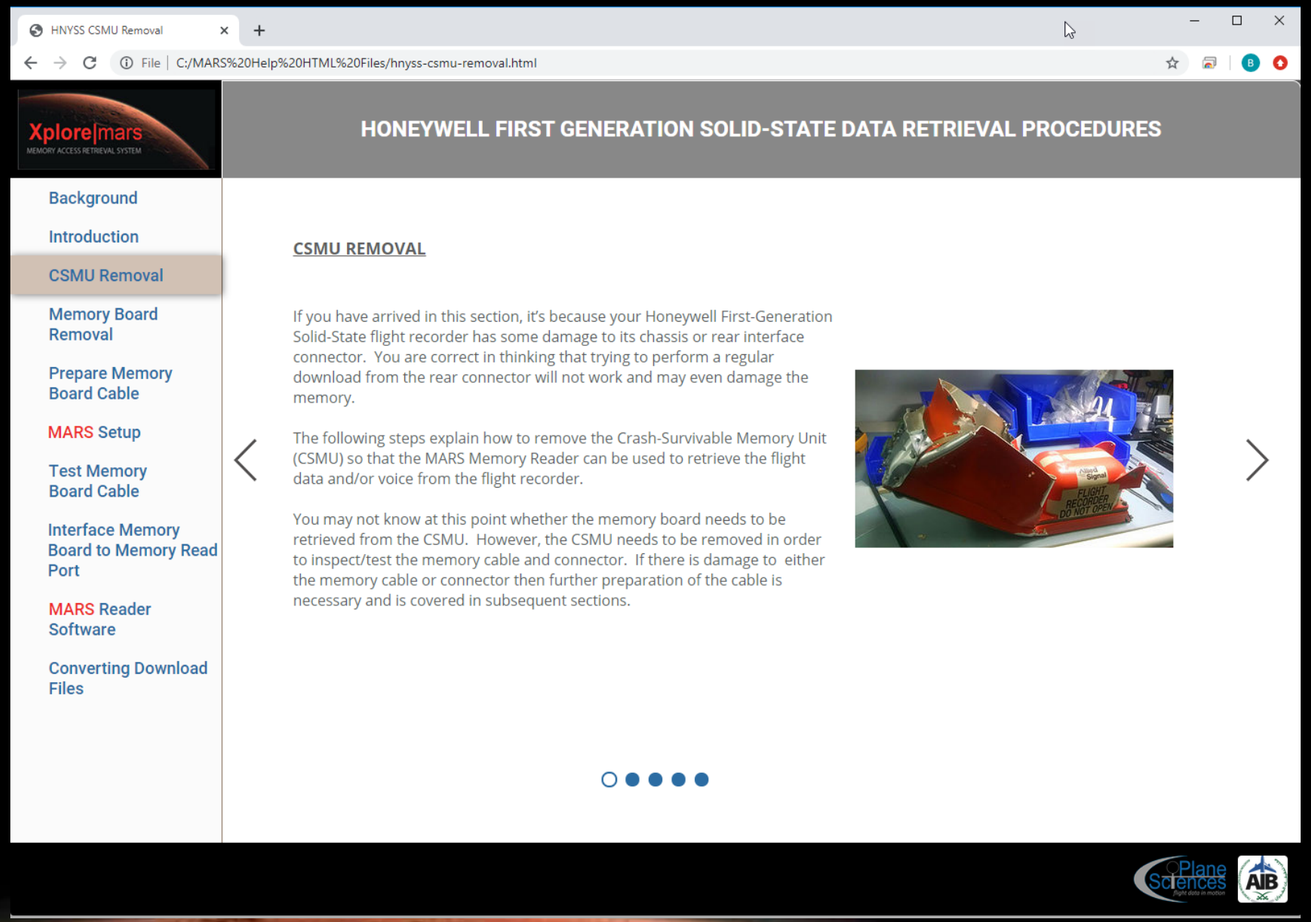
Optional Integrated ESD Work Bench

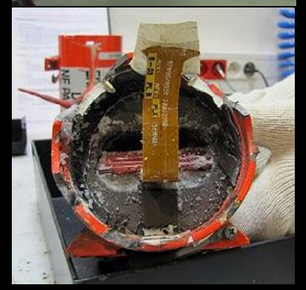
The optional **MARS** ESD bench comes with:

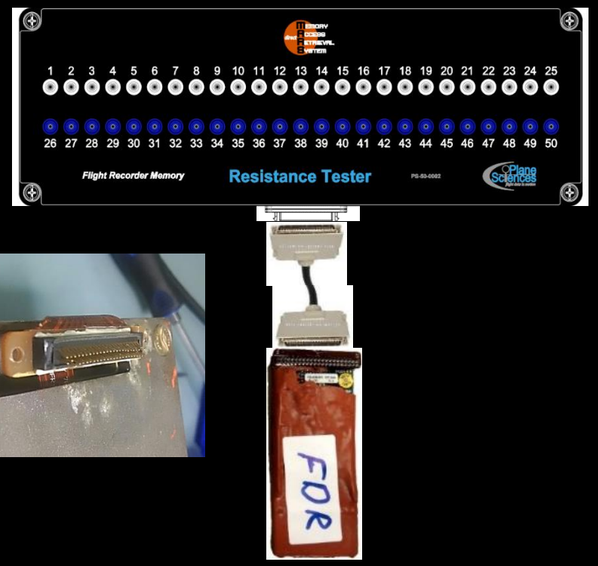
- Optical microscope with digital camera.
- Ultrasonic memory wash bath.
- Memory drying oven.
- AC and DC power supplies, rack mounted control panel and power adapter cables for undamaged replay.
- **MARS** hardware and software.
- Digital multi-meter for memory resistance tests.
- Optical magnifying ring with light.
- Desktop PC with mini audio analysis system (multi-track audio interface, iPad controlled mixer, headphone distribution amplifier and four powered monitor speakers).

MARS Software Screenshots

MARS software includes step by step procedures for recorder teardown and memory preparation for each recorder type.







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FDR/CVR Memory Access Retrieval System

Plane Sciences flight data in motion

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AIB

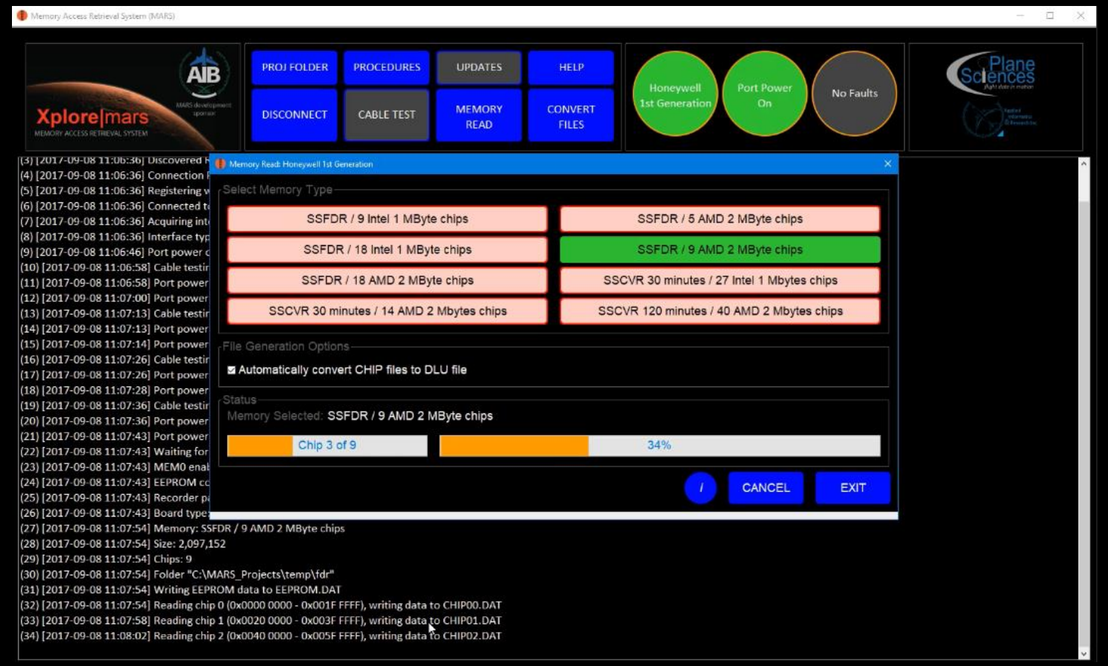
MARS Info Pack v6

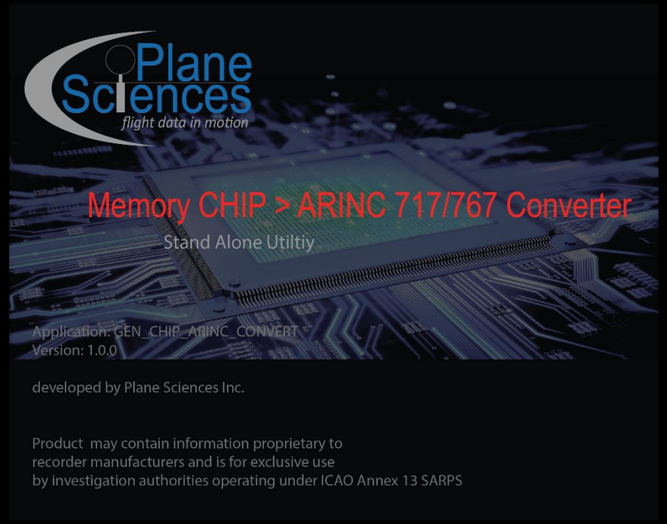
MARS Software Screenshots

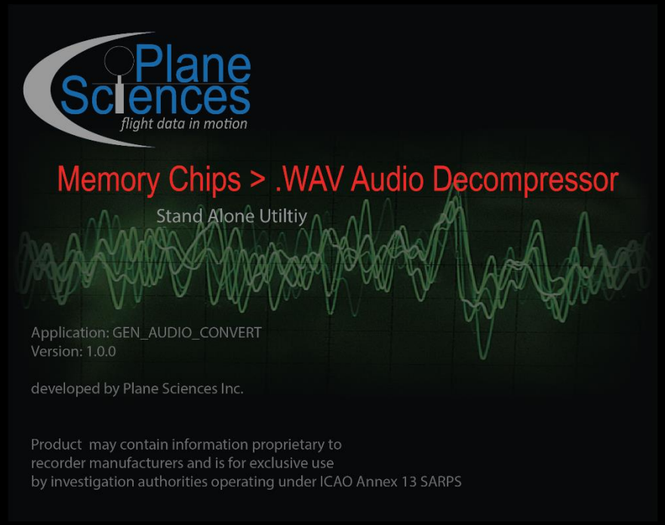
MARS software is extremely simple and intuitive to use. It includes a ribbon connector test procedure shown below to ensure that there are no shorts in the ribbon connector between the memory module and the MARS replay hardware unit by testing each set of memory address lines 10 consecutive times for a PASS.

MARS Software Screenshots

Screen shot of the MARS Chip Download Process. MARS tries to figure out the memory type installed and puts the recommended choice highlighted in green as shown below. MARS includes everything required to reassemble the data back into an AIRINC 717/767 data file or .WAV file in the case of audio. The converters and decompressors are designed for accident investigations to handle occasional problematic playbacks. The converters are also byte-by-byte compatible with the manufacturer's decompressors.

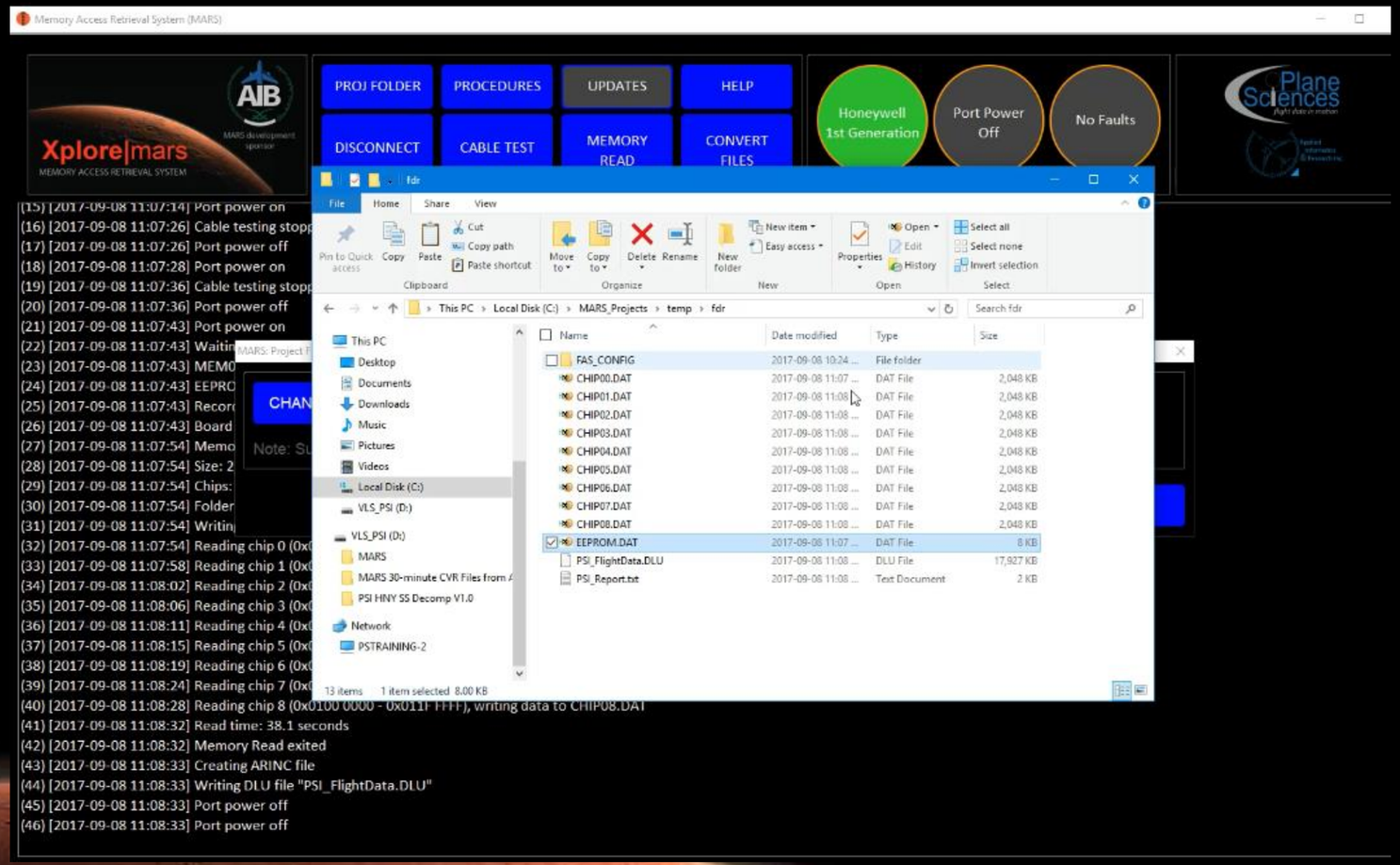






MARS Software Screenshots

Windows folder showing each individual CHIP file, the EEPROM file and the .DLU file after MARS download



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FDR/CVR Memory Access Retrieval System

MARS Recorder Models

MARS V3.0 (current version)

- Honeywell 980-4700-XXX SSFDR
- Honeywell 980-4120-XXX SSUFDR
- Honeywell 980-6020-XXX 980-6022-XXX SSCVR
- Honeywell 980-6025-XXX DVDR
- Honeywell 980-4710-XXX AR-FDR SSFDR
- Honeywell 980-6023-XXX AR-CVR SSCVR
- Honeywell 980-6021-XXX AR-Combi
- Fairchild (L-3 Com) F1000 FDR
- Honeywell 980-4750-XXX HFR5-D
- Honeywell 980-6032-XXX HFR5-V

MARS PACK and GO Service

What do you do for the recorders MARS cannot yet handle? To bridge this gap as MARS develops and to avoid authorities having to continue to build and maintain an inventory of Golden Chassis bench units with matching firmware for the rare temporary use as a download bench unit, Plane Sciences now offers a PACK and GO Service. A Plane Sciences SME will hand deliver power cables, download interface, interface cables, and a Golden Chassis (AMO certified working flight recorder) with investigation kit installed (where applicable) to support an official investigation download/replay for recorder types not yet handled by MARS. PACK and GO is INCLUDED for all supported MARS customers.

Our current inventory covers the majority of all recorder types in use in commercial aviation. It simply makes more sense for authorities to 'share' bench units through our PACK and GO Service rather than purchase and maintain your own inventory for such rare use. PACK and GO is intended to encourage early buy-in for authorities considering joining the MARS family. Early adopters enable us to develop MARS to ultimately eliminate the need for PACK and GO.

MARS + PACK AND GO has you covered...

+

+

Plane Sciences Subject Matter Expert (SME) Bob Hoyle, CTO, Plane Sciences, assists AIB Nigeria with the playback of severely crash-damaged recorders on site in Abuja, Nigeria.

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FDR/CVR Memory Access Retrieval System

Plane Sciences flight data in motion

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MARS Benefits

- **MARS** is designed as one integrated system to eventually handle all solid state recorders with associated economies of scale.
- **MARS** represents the best opportunity to recover all of the data in problematic cases since it does not reply on the EEPROM status, recorder firmware or decompressors which were designed for normal replay.
- **MARS** reduces/eliminates the reliance on OEM; there is no requirement for OEM's to maintain expertise on the internals of their recorder designs to be able to trouble shoot rare problems that experience has shown, surface from time to time in accident investigations.
- **MARS** eliminates purchasing overlapping replay kit, replay software, etc. intended for airlines with limited recorder types; authorities have to handle all recorder types and there is benefit to consolidated analytical processes regardless of recorder type.
- Experience in recovery of data at the memory level, on a regular basis, instead of memory substitution will help uncover potential inadequacies in documentation and provide transparency into the process.
- No need to obtain a large inventory of (Golden Chassis) bench units with matching firmware; **MARS** PACK and GO Service is an interim means for authorities to share a centralized source of *maintained* bench units rather than each authority maintain their own inventory for rare or no use.

It is important to review documentation now while SME's on recorder types are still around!

Research & Development

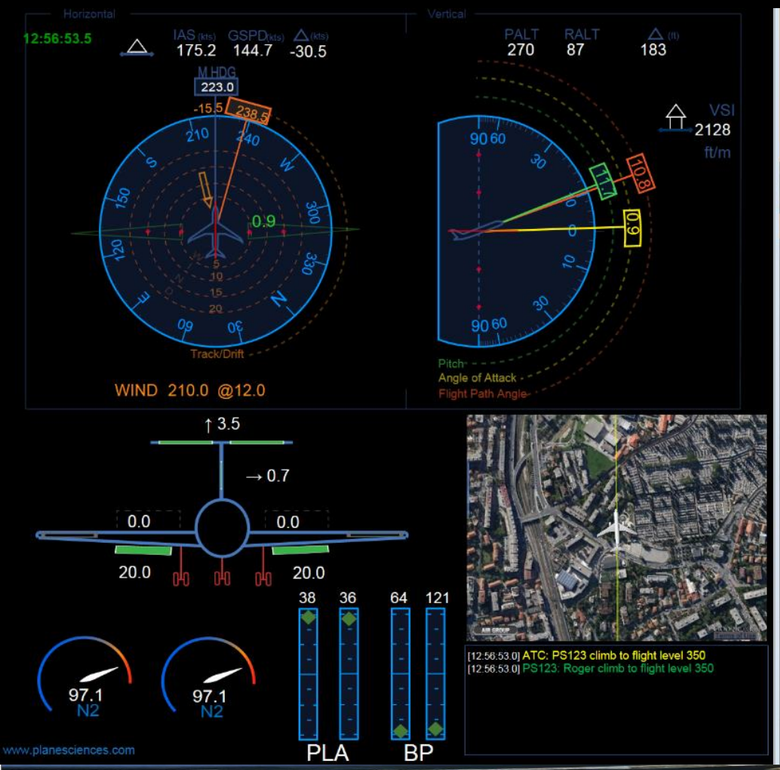
As of July 2018, Plane Sciences is a National Research Council of Canada Industrial Research Assistance Program (NRC IRAP) client. NRC IRAP is assisting Plane Sciences by providing R&D funding as well as subject-matter-expertise resources for the development of the MARS project

National Research Council Canada

Conseil national de recherches Canada

https://www.nrc-cnrc.gc.ca/eng/irap/

Optional lumina|2d and lumina|3d Software



Plane Sciences and Applied Informatics & Research (AIRINC) are co-developing the next generation suite of flight data analysis tools based on the long standing Insight product line and the latest technology in the latest FAS-INV software. We tentatively plan to brand the next generation product line for Q1 2021 as the 'lumina' product line.

- lumina|mars > Damaged Recorder Memory Access Retrieval System (includes bit level editing)
- lumina|2d > Primary ground station with extensive plot/list capability (currently Insight|Analysis but under redevelopment and currently called FAS-INV)
- lumina|3d > Primary flight animation tool + lumina|2d (currently FAS-INV)
- lumina|trend > Primary flight data monitoring tool (currently Insight|FDM) + lumina|2d
- lumina|trend+ > Primary FDM tool + lumina|2d + lumina|3d