

Concept of Operations with DCART



Ryan Hamel

Lowell Digisonde International, LLC

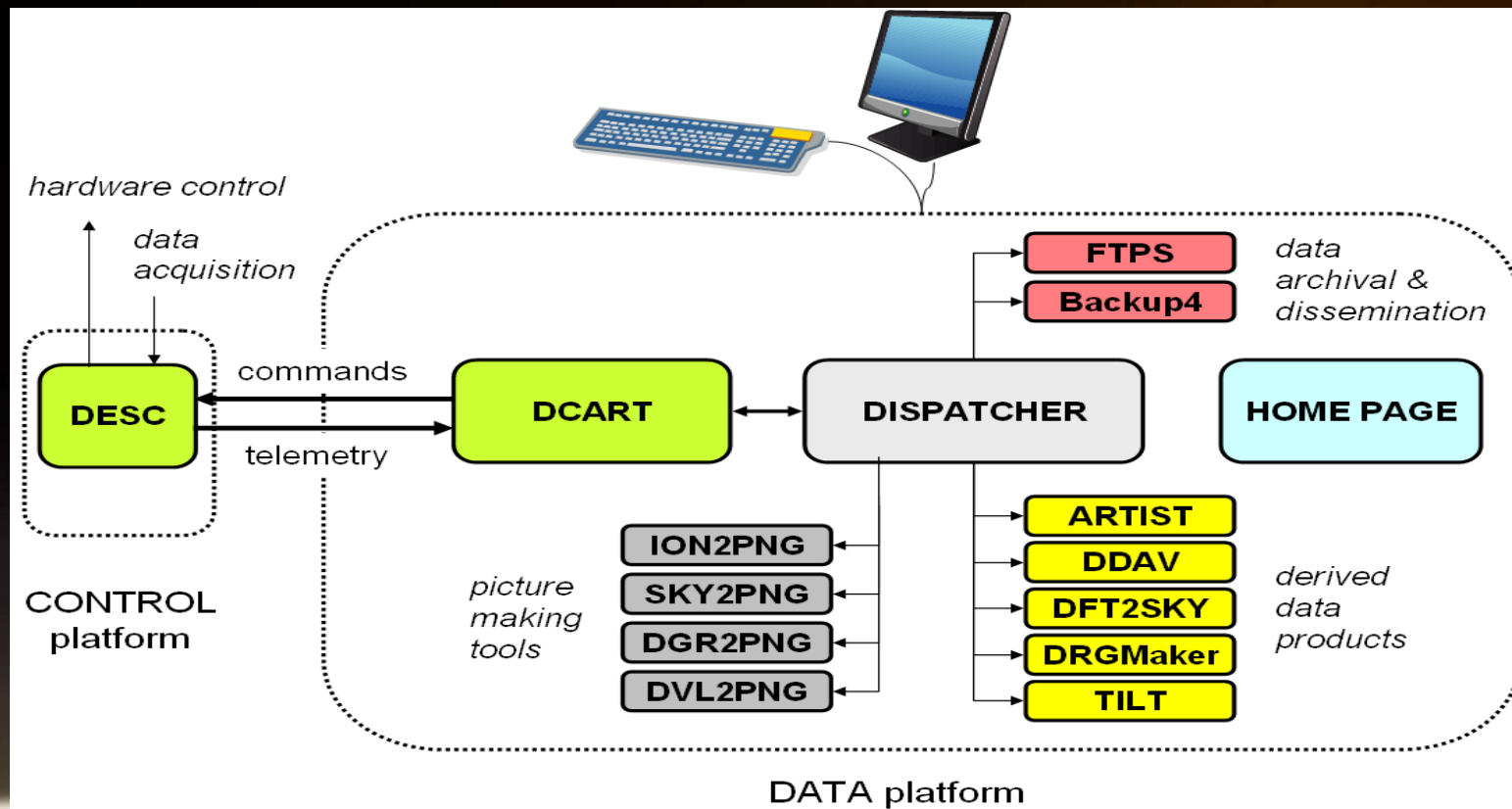
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Outline

- Overview of DPS-4D software
- DCART interface basics
- Concepts for digisonde control and experiment planning
- Additional Presentations
 - Common errors in measurement programming Ivan
 - Under the hood (software design) – Alex
 - Working groups – Ivan & Alex

Top Level View of Software



A word on DESC

- Digisonde Embedded System Control
- DESC is the software running in RTEMS on the Control Computer that interface with the hardware.

DCART : Main Functions

- PLANNING EXPERIMENTS
 - Program design
 - Schedule design
 - Daily Ops design
 - Campaign design
- DATA VISUALIZATION
 - Science data
 - Housekeeping data
- MANUAL CONTROL
 - Start and stop



Welcome to DCART

DCART v1.4.1 Millstone Hill, model DPS-4D (DESC connected since 2011.05.01 18:59:56.825)

File Action Tools Options Help

STOP Soft STOP Auto Info


Command: Flush SST Queue send

ACTIVE PROGSCHED Sounding Mode Built-In Test Channel Equalizing Tracker Calibration

Enable Data Display Display Options Presentation ionogram View Preface

TO START VISUALIZATION OF THE REAL-TIME DATA, ENABLE DATA DISPLAY

DCART v 1.4.1
Copyright (c) UMLCAR 2006-2011



University of Massachusetts Lowell
Center for Atmospheric Research
www.umlcar.uml.edu

DCART

UMASS

Disable the real-time display before leaving system running unattended

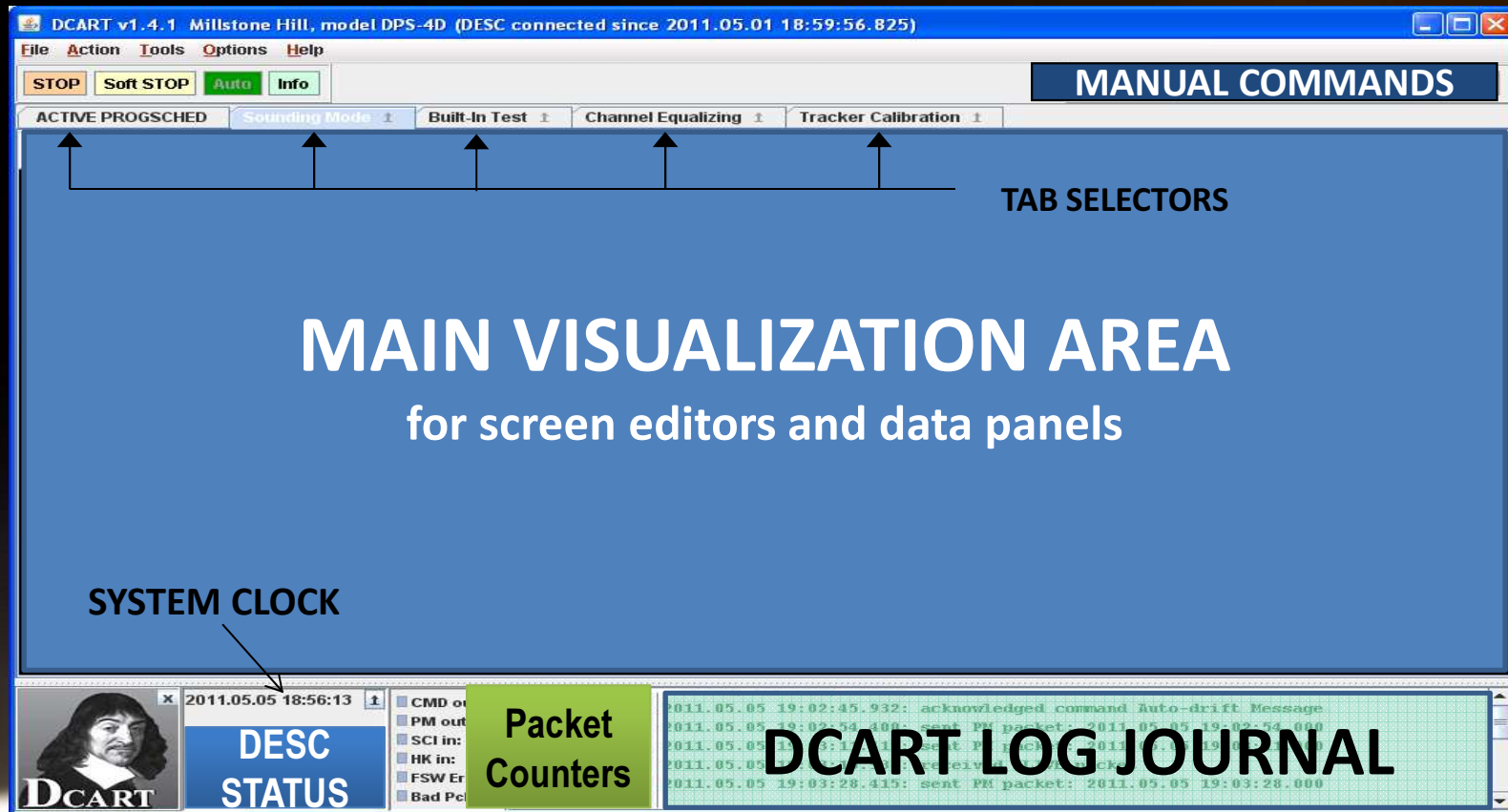
2011.05.05 18:56:13

STATE: Automatic
S3 P2 68%

CMD out:	328
PM out:	66667
SCI in:	82972571
HK in:	15497
FSW Errs:	0
Bad Pckts:	0

2011.05.05 19:02:45.932: acknowledged command Auto-drift Message
2011.05.05 19:02:54.400: sent PM packet: 2011.05.05 19:02:54.000
2011.05.05 19:03:11.415: sent PM packet: 2011.05.05 19:03:11.000
2011.05.05 19:03:15.930: received ALIVE packet
2011.05.05 19:03:28.415: sent PM packet: 2011.05.05 19:03:28.000

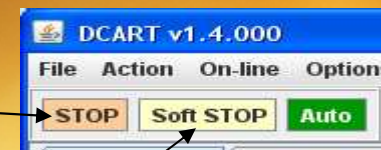
DCART Screen Organization



Top Level Color Concept

- **RED** : PROBLEM that requires operator's attention
- **YELLOW** : important option or control
- **ORANGE** : "hazardous" operation that affects quality/amount of collected data
- **GREEN** : working normally
- **BLUE** : information

Stop immediately



Finish measurement and stop

RED = Requires Attention

DCART v1.2.06 (DESC connected since 2009.05.11 (131) 04:54:37)

File Action On-line Options Help

STOP Stry Diag Auto Info Save Product Files: NONE Save Raw Files: ALL Command: Flush SST Queue send

EDITED PROGSCHED Sounding Mode Built-In Test Channel Equalizing Tracker Calibration HK Header DVLP TOOLS

Prog # Title Timesta Author

Schd 001 BIT 2009.0 IG

SST 002 Day No 2009.0 IG

003 Night N 2009.0 IG

004 F Day N 2009.0 IG

005 F Night 2009.0 IG

006 E Day 2009.0 IG

007 F Day R 2009.0 IG

008 empty

009 empty

010 CCEQ 2009.0 IG

011 AG Day 2009.0 IG

012 AG Night 2009.0 IG

013 Tracker 2009.0 IG

014 empty

015 Day LT 2009.0 IG

016 Night L 2009.0 IG

017 F Day L 2009.0 IG

018 F Night 2009.0 IG

019 E Day L 2009.0 IG

020 empty

021 empty

022 empty

023 empty

024 empty

025 empty

026 empty

027 empty

028 empty

029 empty

030 empty

031 empty

032 empty

033 empty

Operations with program 004

Rename Copy Undo Clear

Info Paste Redo Verify

Load selected Run selected

PROGRAM #004 Operation: Sounding Mode Measurement View Design Error

FREQUENCY STEPPING

Freq Stepping Law: log

Lower Freq Limit: 1000 [kHz]

Upper Freq Limit: 15000 [kHz]

Coarse Freq Step: 2 %

Number of Fine Steps: 4

Fine Freq Step: 50 [kHz]

Fine Step Multiplexing: enabled

Total frequencies: 552

RANGE SAMPLING

Start Range: 80 [km]

Number of Samples: 512

Inter-Pulse Period: auto 2 [5ms]

Range coverage: 80 to 1357.5 / max 1499 km

PULSE INTEGRATION

Number of Integrated Repeats: 4

Interpulse Phase Switching: disabled

Pulses/Freq : CIT : total 16 : 64 : 8832

CIT time: 640 ms

Exact Running Time: 1 m 28 s 350 ms

SYSTEM SETTINGS

Constant Gain: full gain (50 dB)

Auto Gain Control: use existing gain table

Rx Gain: -12 dB

Wave Form: 16-chip complementary

Polarizations: O and X Antennas enabled: 1 2 3 4

☒ Radio Silent ☒ Standard ☐ Oblique ☐ Compatible

DATA PROCESSING

Final Processing Step: Ionogram Calculation

☒ RFIM ☐ in FPGA

☒ Channel EQ

☐ Data Reduction

☐ Clear data below MPA

View Process Chain

OUTPUT FILES

☒ Save product file ☐ Save raw file

RSF

DESC-to-DCART traffic: 8832 packets = 73,340 kB

Internal data rate: 6,641 kbit/s

Show Active PROGSCHED Activate changes Save as active File: P:\Installation\NewVersions\DCART\Nexion\NEXION_v1.DCD

2009.05.11 14:17:41

DESC Ver: 3.0.0

STATE: Diagnostic

DESC is IDLE

CMD out: 8

PM out: 4

SCI in: 0

HK in: 13

FSW Errors: 2

Bad Packets: 1

07:20:56.234: sent START_PROG packet: prog 1

07:20:56.265: received ACK from STATE_DIAG packet

07:20:56.484: received ACK from START_PROG packet

07:21:50.406: sent PM packet: 2007.04.22 07:21:50.000

07:21:50.406: received ACK from PM packet

07:21:53.500: *** ERROR: ProgSched is empty

RED = Requires Attention

System configuration error

Digisonde will display data but will not produce files with data

products (ionogram)

No measurements will be made if you walk away

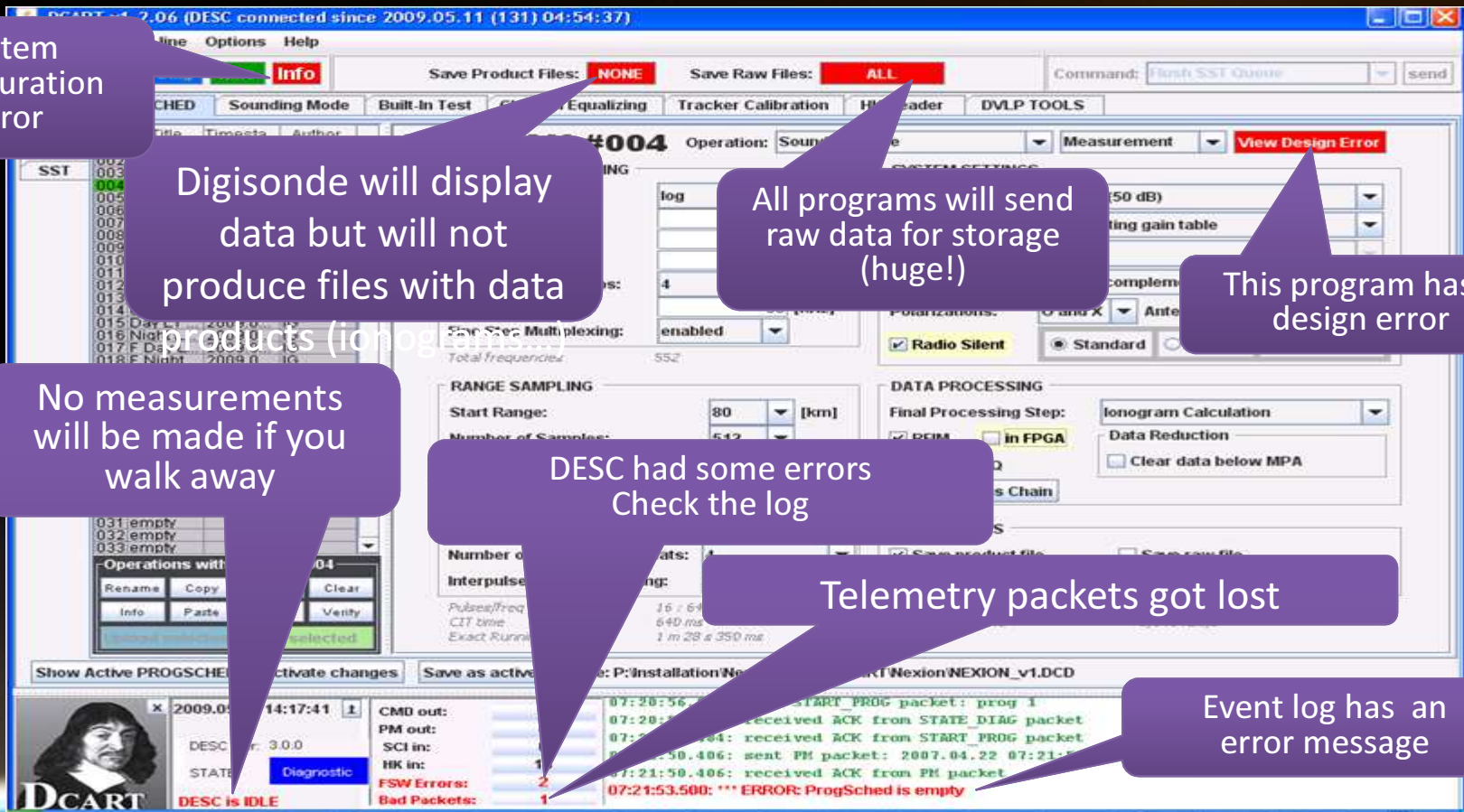
DESC had some errors
Check the log

All programs will send raw data for storage (huge!)

This program has a design error

Telemetry packets got lost

Event log has an error message



Planning Measurements

- Design of Programs
- Design of Schedules
- Design of Schedule Start Times
- Design of Campaigns

Program

- Programs are *usually* measurements that produce science data: Ionogram, Drift / Skymap
- Program Operation
 - **Sounding Mode**, Built-In Test, Channel Equalizing, Tracker Calibration, NoOp
 - **Measurement**, Internal Loopback, HW Test Pattern, SW Test Pattern

Program Example

DCART v1.5.1 Millstone Hill, model DPS-4D (DESC connected since 2014.05.14 20:20:51.187)

File Action Tools Options Help

STOP Stry Diag Auto Info

Save Product Data: ALL Save Raw Data: Per Program Command: Flush SST Queue send

EDITED PROGSCHED Sounding Mode Built-In Test Channel Equalizing Tracker Calibration HK HEADER

Prog	#	Title	Timestamp	Author
Schd	001	BIT	2010.11...	IG
SST	002	Day Nor...	2011.03...	IG
Options	003	Night Nor...	2011.03...	IG
	004	F Day No...	2011.01...	IG
	005	F Night N...	2011.01...	IG
	006	E Day No...	2011.01...	IG
	007	empty		
	008	unknown	2011.08...	
	009	empty		
	010	CCEQ	2013.07...	IG
	011	AG Day	2013.07...	IG
	012	AG Night	2013.07...	IG
	013	Tracker ...	2013.07...	IG
	014	empty		
	015	Day Nor...	2010.07...	IG
	016	5-minute	2011.01...	Als
	017	Day Nor...	2011.11...	IG
	018	empty		
	019	empty		
	020	Test Iono...	2012.04...	RH

Operations with program 002

Rename Copy Undo Clear

Info Paste Redo Verify

Upload program Run program

PROGRAM #002

Operation: Sounding Mode Measurement

FREQUENCY STEPPING

Freq Stepping Law: linear

Lower Freq Limit: 1000 [kHz]

Upper Freq Limit: 13000 [kHz]

Coarse Freq Step: 25 [kHz]

Number of Fine Steps: 2

Fine Freq Step: 5 [kHz]

Fine Step Multiplexing: enabled

Total frequencies 962

RANGE SAMPLING

Start Range: 80 [km]

Number of Samples: 512

Inter-Pulse Period: ☒ auto 2 [5ms]

Range coverage 80 to 1357.5 / max 1499 km

PULSE INTEGRATION

Number of Integrated Repeats: 4

Interpulse Phase Switching: enabled

SYSTEM SETTINGS

Constant Gain: FULL GAIN Tracker(0) and Antenna Switch(0)

Auto Gain Control: use existing gain table

Rx Gain: FULL GAIN-18dB

Wave Form: 16-chip complementary

Polarizations: O and X Antennas enabled: 1 2 3 4

☐ Radio Silent ☒ Standard ☐ Oblique ☐ Compatible

DATA PROCESSING

☒ RFIM ☒ in FPGA Ionogram Calculation

☒ CCEQ Data Reduction

☒ D-Spike ☒ ChipComp ☒ Clear data below MPA

View Process Chain 2-frequency PGH (5 kHz)

OUTPUT FILES

☒ Save product data ☐ Save raw data

RSF

Show Active PROGSCHED Activate changes File: copy of Active PROGSCHED

STATE: Automatic 1%

DCART S24 P34

CMD out: 278

PM out: 9890

SCI in: 16007406

HK in: 2889

FSW Errors: 9

Bad Pckts: 0

2014.05.16 19:02:56.995: Cleared log file: D:\DPSMAIN\WUX2DPS\AUTOLOG\201405160000.LOG

2014.05.16 19:02:56.905: New D:\DPSMAIN\WUX2DPS\AUTOLOG.REM file has been set as an AutodriftMessage.

2014.05.16 19:02:56.905: sent AUTO_DRIFT_MSG packet: 2014.05.16 19:00:00.000, 375km, 7500kHz, 105km, 2400kHz

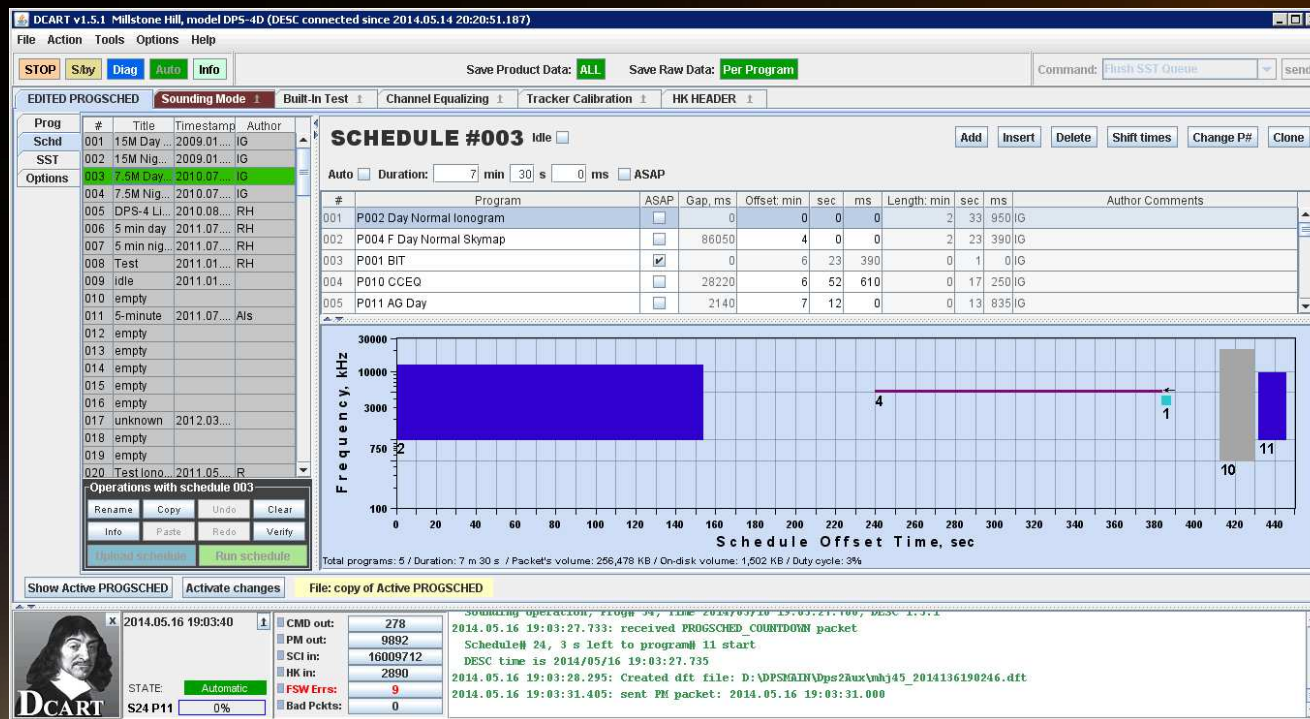
2014.05.16 19:02:56.921: acknowledged command Auto-drift Message

2014.05.16 19:02:57.405: sent PM packet: 2014.05.16 19:02:57.000

Digisonde Schedules

- Digisonde Schedule = repetitive sequence of measurement programs repeated forever
- Concept of “x-ITL”
 - DITL = Day In The Life
 - WITL = Week In The Life
 - 15MITL = 15 Minutes In The Life
 - OITL = Orbit In The Life

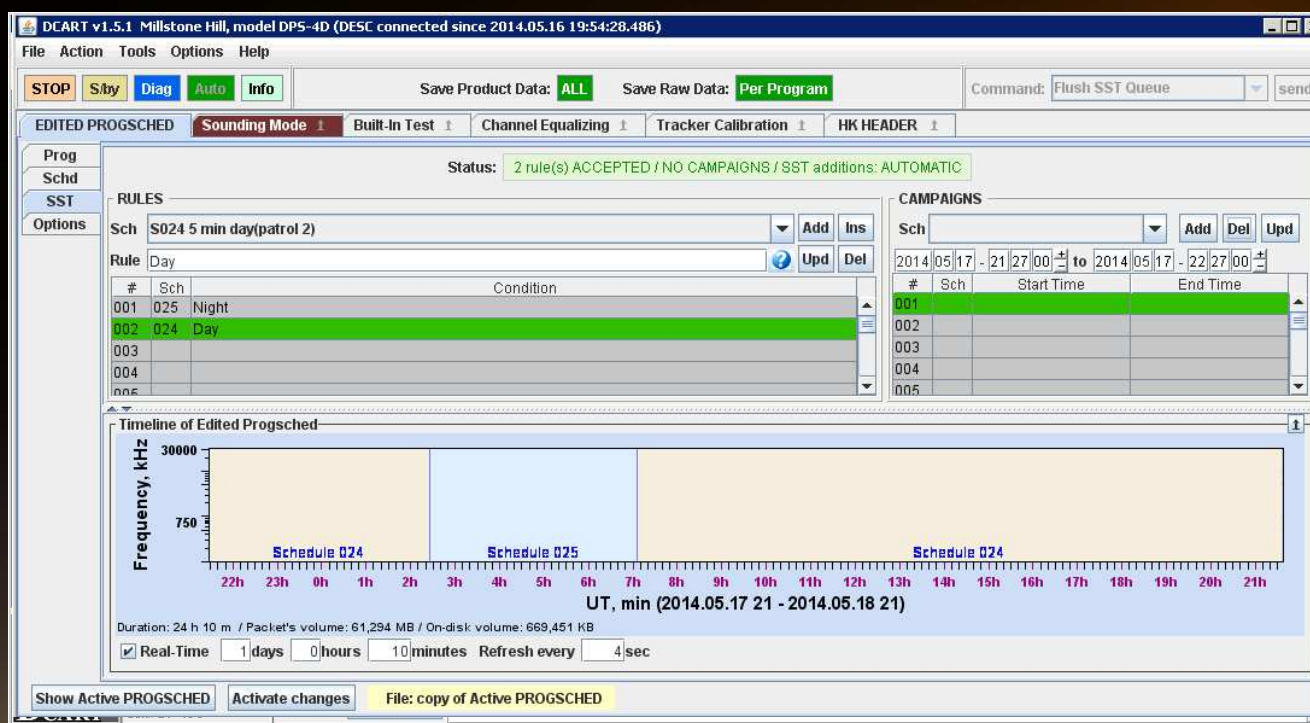
Schedule Example



SST and SST Queue

- DCART determines when to start a particular schedule depending on rules set by the user.
- **SCHEDULE START TIME**
 - Time in UT when a certain schedule starts
 - Good for day/night switching
 - Good for campaigns
- **SST Queue**
 - List of SSTs in DESC (control software)
 - When DESC is in the AUTO mode
 - look at the earliest SST in the Queue
 - when the time is right, start the schedule and remove the SST
 - repeat

Schedule Start Time (SST)



Campaign Mode

built-In Test

Status: 2 rule(s) ACCEPTED / NO CAMPAIGNS / SST additions: AUTOMATIC

RULES

Sch S001 Day 5 min Add Ins

Rule Day (-30m,3h) ? Upd Del

#	Sch	Condition
001	002	Day (-30m,3h)
002	003	Default
003		
004		
005		
006		

CAMPAIGNS

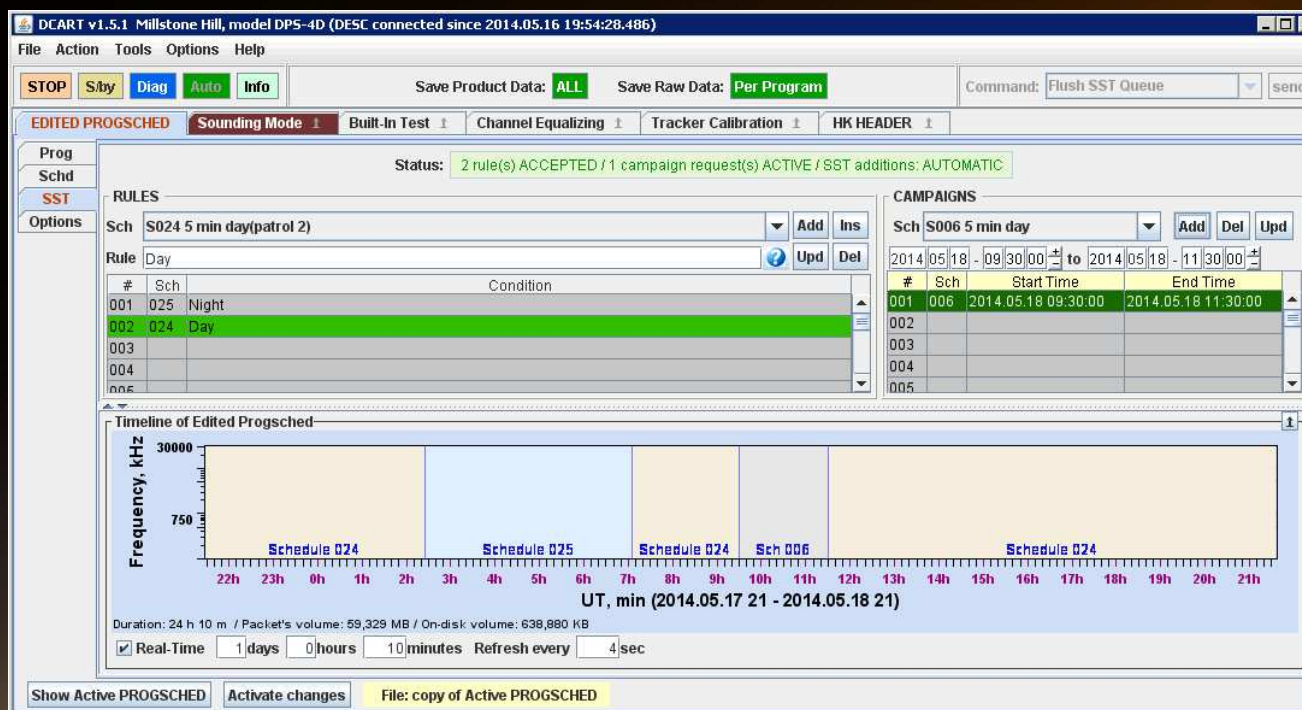
Sch Add Del Upd

2009 01 25 - 13 38 00 ± to 2009 01 25 - 14 38 00 ±

#	Sch	Start Time	End Time
001			
002			
003			
004			
005			
006			
007			

- Just add start and stop UT for a particular schedule, the rule-based DITL will be overwritten
- Campaign requests can be sent to DCART over the FTP as plain text files

Campaign Mode Example



Digisonde Day and Night Schedules

- We recommend different schedules for day and night
- DAY: higher upper frequency, coarser frequency stepping
- NIGHT: lower gain, lower upper frequency, finer stepping, no E-layer drift

EDITED PROGSCHED

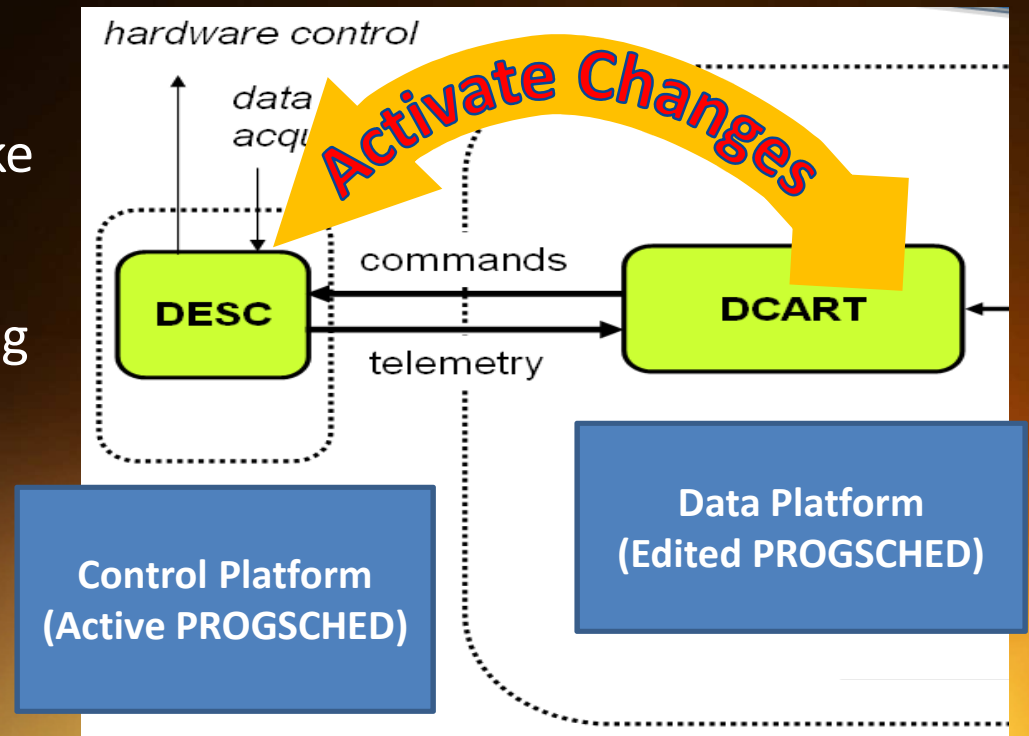
ACTIVE PROGSCHED

Note on Active vs Edited PROGSCHED

- Progschd contains the descriptions of all programs, schedules, SSTs, and campaigns
- User can make changes to programs, schedules, sst without disrupting system operation
- This is accomplished by having two versions of progsched; one on the Control platform and the other on Data platform

Activating Changes

- The user can view the active progsched sent from the Control Platform but not make changes
- When editing programs and schedules the user is changing the edited progsched on the Data Platform
- Once editing of progsched is complete remember to Activate Changes!



Interface showing Active PROGSCHED

ACTIVE PROGSCHED **Sounding Mode** Built-In Test Channel Equalizing Tracker Calibration HK HEADER

Prog	#	Title	Timest...	Author
Schd	001	BIT	2010.1...	IG
SST	002	Day No...	2011.0...	IG
Options	003	Night...	2011.0...	IG
	004	F Day...	2011.0...	IG
	005	F Night...	2011.0...	IG
	006	E Day...	2011.0...	IG
	007	empty		
	008	unkno...	2011.0...	
	009	empty		
	010	CCEQ	2013.0...	IG
	011	AG Day	2013.0...	IG
	012	AG Night	2013.0...	IG
	013	Tracke...	2013.0...	IG
	014	empty		
	015	Day No...	2010.0...	IG
	016	5-minute	2011.0...	Als
	017	Day No...	2011.1...	IG
	018	empty		
	019	empty		
	020	Test lo...	2012.0...	RH

PROGRAM #002 Operation: **Sounding Mode** Measurement:

FREQUENCY STEPPING

Freq Stepping Law: **linear**

Lower Freq Limit: **1000** [kHz]

Upper Freq Limit: **13000** [kHz]

Coarse Freq Step: **25** [kHz]

Number of Fine Steps: **2**

Fine Freq Step: **5** [kHz]

Fine Step Multiplexing: **enabled**

Total frequencies **962**

RANGE SAMPLING

Start Range: **80** [km]

Number of Samples: **512**

Inter-Pulse Period: ☒ auto **2** [5ms]

Range coverage **80 to 1357.5 / max 1499 km**

PULSE INTEGRATION

Number of Integrated Repeats: **4**

Interpulse Phase Switching: **enabled**

SYSTEM SETTINGS

Constant Gain: **FULL GAIN Tracker(9) and Antenna Switch(0)**

Auto Gain Control: **use existing gain table**

Rx Gain: **FULL GAIN-18dB**

Wave Form: **16-chip complementary**

Polarizations: **0 and X** Antennas enabled:

☐ Radio Silent ☒ Standard ☐ Oblique ☐ Compatible

DATA PROCESSING

☒ RFIM ☒ in FPGA **Ionogram Calculation**

☒ CCEQ

☒ D-Spike ☒ ChipComp

☒ Clear data below MPA

2-frequency PGH (5 kHz)

OUTPUT FILES

☒ Save product data ☐ Save raw data

RSF

Operations with program 002

Rename Copy Undo Clear

Info Paste Redo Verify

Upload program... **Run program**

Show Edited PROGSCHED

Interface showing Edited PROGSCHED

EDITED PROGSCHED **Sounding Mode** Built-In Test Channel Equalizing Tracker Calibration HK HEADER

Prog	#	Title	Timestamp	Author
Schd	043	empty		
SST	044	Day Ion d...	2011.12....	RH
Options	045	Night Ion ...	2011.07....	RH
	046	empty		
	047	empty		
	048	empty		
	049	Day Nor...	2013.08....	IG
	050	Day Nor...	2013.12....	IG
	051	Night Nor...	2013.07....	IG
	052	Day Shor...	2012.01....	AK
	053	empty		
	054	empty		
	055	unknown	2012.03....	
	056	empty		
	057	empty		
	058	empty		
	059	empty		
	060	new sch ...	2011.08....	GMK
	061	empty		
	062	empty		

Operations with program 050

Rename	Copy	Undo	Clear
Info	Paste	Redo	Verify
Upload program		Run program	

PROGRAM #050

Operation: Sounding Mode Measurement

FREQUENCY STEPPING

Freq Stepping Law: linear
Lower Freq Limit: 1000 [kHz]
Upper Freq Limit: 14000 [kHz]
Coarse Freq Step: 25 [kHz]
Number of Fine Steps: none
Total frequencies 521

RANGE SAMPLING

Start Range: 80 [km]
Number of Samples: 512
Inter-Pulse Period: ☒ auto 2 [5ms]
Range coverage 80 to 1357.5 / max 1499 km

PULSE INTEGRATION

Number of Integrated Repeats: 8
Interpulse Phase Switching: enabled

SYSTEM SETTINGS

Constant Gain: FULL GAIN Tracker(9) and Antenna Switch(0)
Auto Gain Control: use existing gain table
Rx Gain: FULL GAIN -24dB
Wave Form: 16-chip complementary
Polarizations: O and X Antennas enabled: 1 2 3 4
☐ Radio Silent ☒ Standard ☐ Oblique ☐ Compatible

DATA PROCESSING

☒ RFIM ☒ in FPGA Ionogram Calculation
☒ CCEQ Data Reduction
☒ D-Spike ☒ ChipComp ☒ Clear data below MPA
[View Process Chain](#)

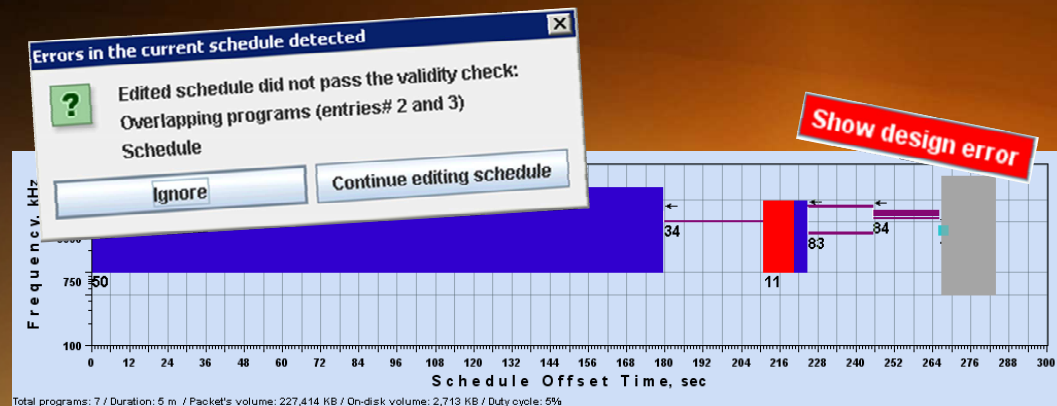
OUTPUT FILES

☒ Save product data ☐ Save raw data
UMS compressed x 1

Show Active PROGSCHED Activate changes File: copy of Active PROGSCHED

Additional Tips

- Backup entire program and schedule definition file, D:\Dispatch\Control\progsched ← just copy the file
- Be wary of using a single program in many schedules
- Usually I find it easier to copy a program and use it in one or few schedules



Advanced Interface Features

- Programming and analysis of Cross-Channel Equalizing (CCEQ) data,
- Programming and analysis of Tracking Filter Calibration data,
- Direct hardware commanding,
- Optional production of raw and derived products
- Commanding of DESC into Diagnostic and Standby state for manual uploads, and
- Manual production of SSTs

Dalu

감사합니다

Gracias

Danke

Ευχαριστίες

THANK YOU

Obrigado

Köszönöm

Tack

Grazie

Спасибо

Dank

谢谢

Merci

ありがとう

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BACKUP

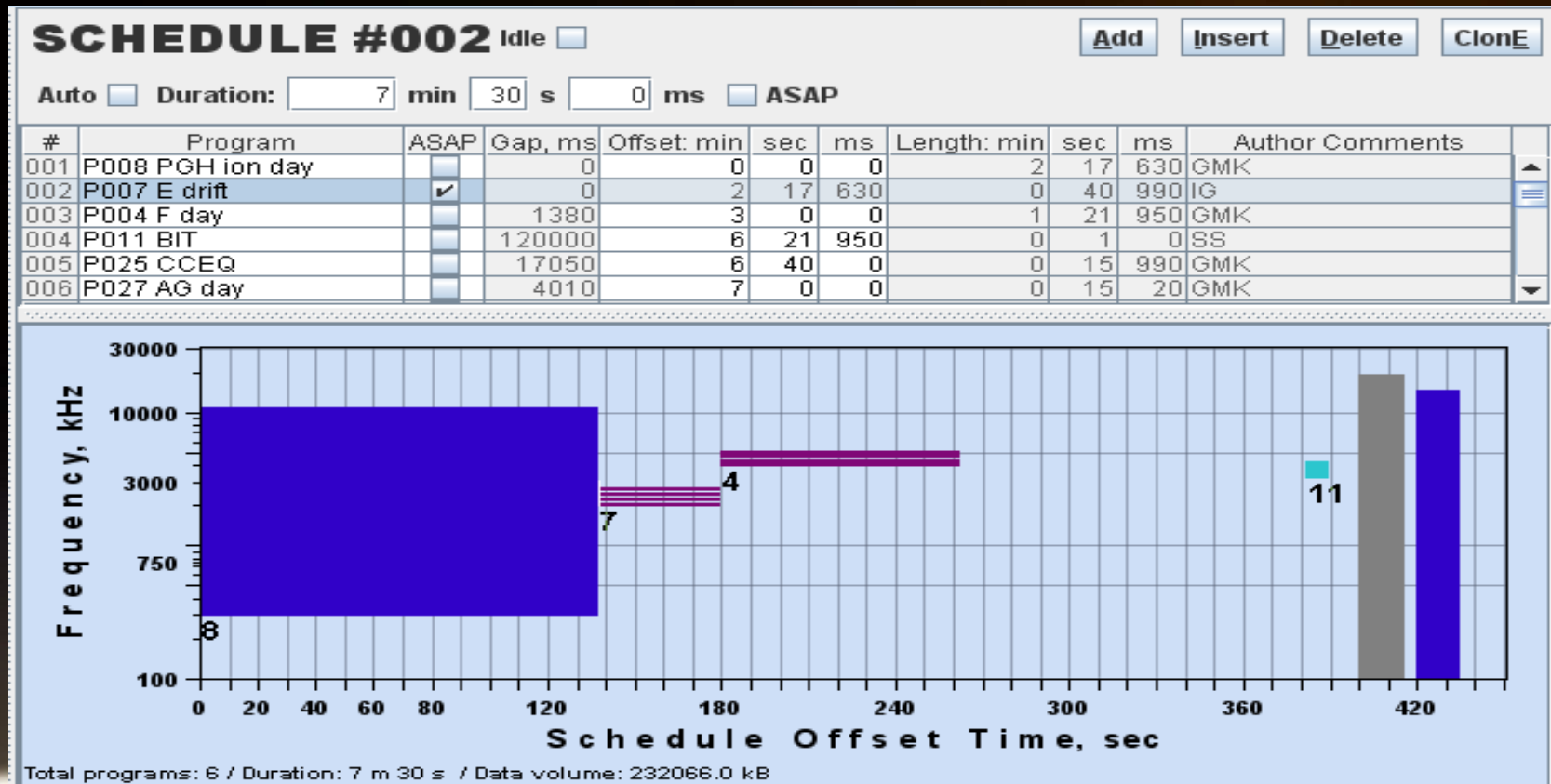
From HITL to x-ITL

- Digisonde 256, DPS-4: HITL
 - Hour In The Life (HITL) is one schedule
 - E.g., 4 times a hour
- Digisonde 4D: x-ITL
 - Any-period-of-time In The Life (x-ITL)
 - Inspired by IMAGE RPI mission planning
 - Multiple programs run at irregular intervals
 - E.g., 5MITL is 5 minutes in the life
 - Equivalent to 12 times an hour, only that **one copy of 5MITL is sufficient instead of 12 copies to describe for HITL**
 - Advantage becomes clearer when 5MITL has more than 2-3 programs

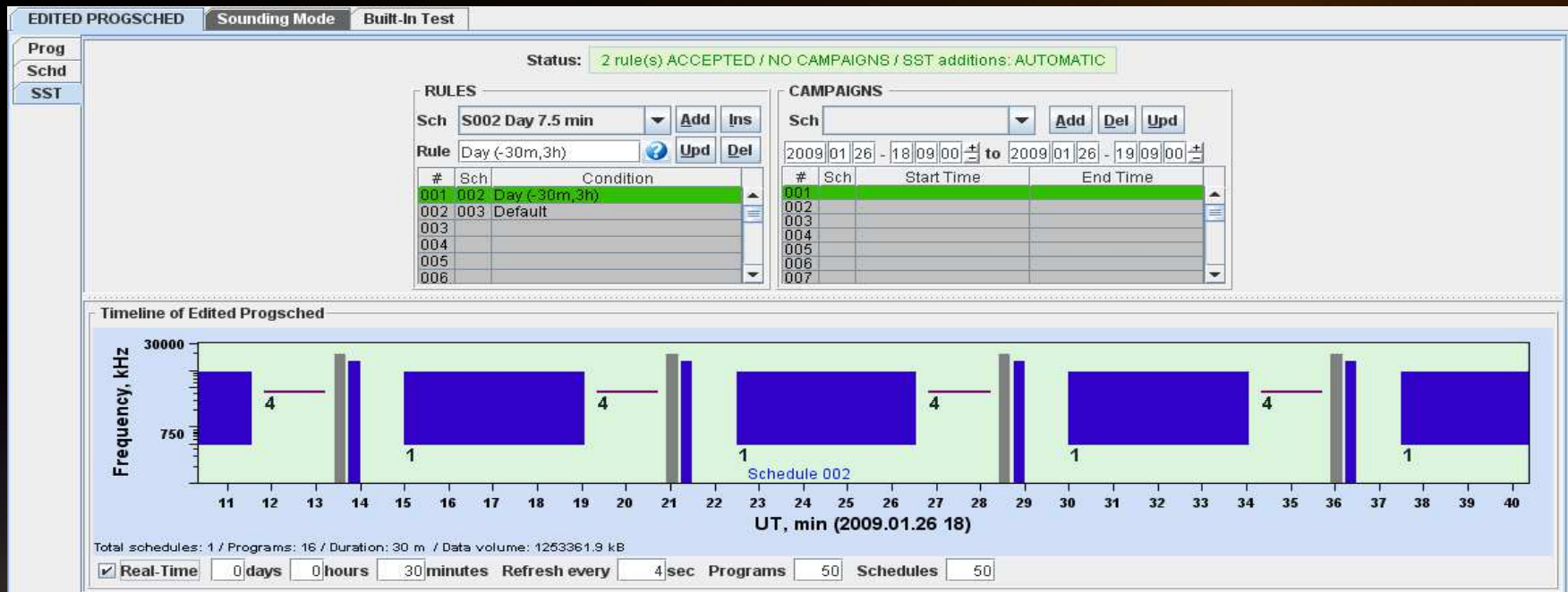
DCART Schedule Editor

with xITL

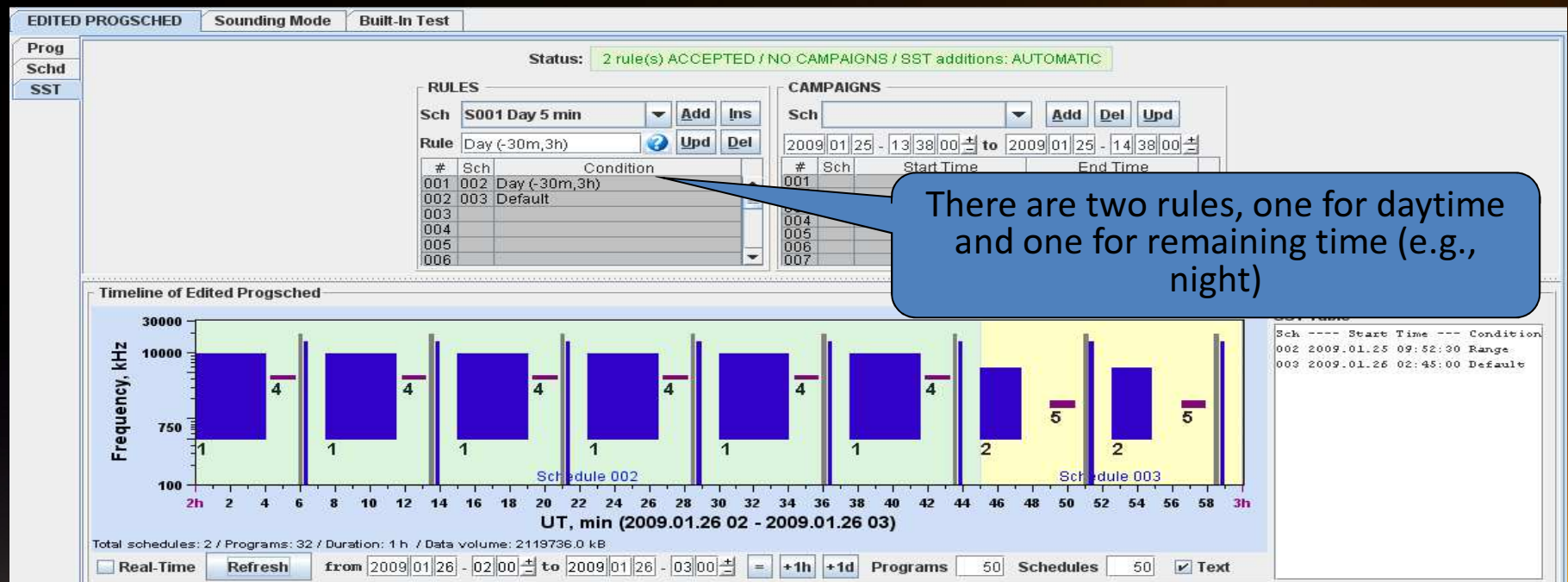
7.5MITL



DCART Timeline Display



EASY SST SCENARIO



There are two rules, one for daytime and one for remaining time (e.g., night)

- DAY = schedule 2
- NIGHT = schedule 3

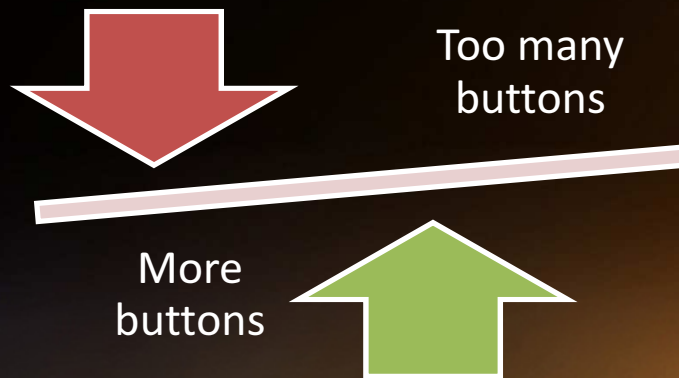
Replenishing SST Queue

- DCART calculates new SSTs
- Two main mechanisms to add SSTs to the Queue:
 - RULE-BASED
 - Define rule(s) for automatic SST generation
 - E.g., day and night schedules
 - CAMPAIGN
 - Specify start and stop UT for a particular schedule

PRIORITY OF CAMPAIGN IS HIGHER

TWO USER MODES OF INTERFACE

(Abbreviated and Advanced)



- Conflict between flexibility and usability
- Two user modes
 - Normal
 - Advanced

Queue Replenishing Modes

- BUILD FOR A TIME PERIOD
 - Enter start UT
 - Enter stop UT
 - Push “Rebuild” button
 - Get list of SSTs
 - Send all SSTs to DESC
 - DESC makes them happen
- REPLENISH AUTOMATICALLY
 - No need to type times
 - DCART uses rules and campaign times to prepare SSTs
 - Shortly before the start time, the SST is sent to DESC
 - DESC makes it happen

TYPICAL FOR SPACE MISSIONS

TYPICAL FOR DIGISONDE OPS

Queue Replenishing Modes (2)

- BUILD FOR A TIME PERIOD^{typical operation}
 - Rebuild SSTs
 - Display the timeline
 - Correct rule mistakes manually
 - Send to DESC or save as a script
- REPLENISH AUTOMATICALLY
 - Display the timeline
 - No manual correction of generated SSTs possible
 - Adjust rules or campaign times
 - Repeat

MISTAKES CAN BE CORRECTED

RELIABLE RULE ENGINE IS NEEDED