



Housekeeping Telemetry Viewer: 10 years of operations

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HKTV stands for House-keeping Telemetry Viewer.

In essence, HKTV is a **packet**¹ viewer and analyzer.

¹What is packet? A chunk of data with some properties: length, type (TM/TC), APID. Example: CCSDS packet.



Motivation



HKTV development has been initiated by EUMETSAT exactly 10 years ago as an in-house project to enable the analysis of IASI²

data collected during AIT at Satellite level:

- telemetry
- telecommands
- science data.

For:

- reporting, trending, investigation, and
- to preserve knowledge in long term program.

²Part of EUMETSAT Polar System, on board Metop-A,B,and C satellite.

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History



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HKTV in 2009:

- Monolithic Java application (only standalone processing on one PC)
- Java 5 and 6 support
- GUI based on Java Swing
- Proprietary archive format
- Plotting based on JFreeChart
- Reporting based on JFreeReport

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HKTV past and current use



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HKTV in 2009-2019 supports:

- IASI on Metop
- MHS on Metop
- IASI-NG on Metop-SG
- METIMAGE on Metop-SG
- Metop-SG (all instruments)

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Good tools survive... with little maintenance



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HKTV in 2019:

- Monolithic Java application (main target platform: MacOS)
- Distributed processing support via message bus (ActiveMQ)
- PUS support
- Java 8-13 support
- GUI based on Java Swing
- Archive format: proprietary and MongoDB
- Plotting based on JFreeChart
- Reporting based on JFreeReport
- Synoptic displays based on SVG/HTML/JavaScript and JavaFX

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Concepts



HKTV follows the following concepts:

- **One Click** satisfy the user, not the requirement
- AGILE
- **KISS** (keep it small and simple): if functionality is needed in >90% of use cases, it goes into the kernel, otherwise it's implemented as an extension (dedicated java package per instrument). This keeps the kernel very simple.
- **YAGNI** (you aren't gonna need it): never process anything unless really needed. Opaque packets remain the only data always available. Everything else, e.g. parameters are extracted only upon request. Plots painted only if visible.
- **CI/CD** with automated testing



Architecture



HKTV is built around a **data bus**. Every CCSDS packet is pushed through this bus. The bus is implemented in ActiveMQ, meaning that you can have both local and remote clients.

Once you want to add an additional component (a window, data processing, specific storage, etc.) just subscribe to the data bus.

Each data consumer runs in a separate thread.



Main window



Test display				Data	packets		
Test text Test switches Test color ch	angers Get fields for subscription Test data up	reset		No.	OBT	Local time	PUS
			K 7	1	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
Activities				2	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
Time	Activity	Status		3	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
				4	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
				5	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
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				7	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
				8	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
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				10	2004-01-28 17:34:36.249	2019-11-11 12	200.3
					2004-01-28 17:34:30:245	2019-11-11 12	2 2 5
Time	From	Message	Exception	13	2004-01-28 17:34:38.710	2019-11-11 12	200.3
2019-11-11 12:07:40:608	org.eumetsat.hktv.ui.HTMLUserDisplayPanel	test user display html: field PPTr1030 was not found		14	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
2019-11-11 12:07:40.610	org.eumetsat.hktv.ui.HTMLUserDisplayPanel	test user display html: field PPTr1072 was not found		15	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
2019-11-11 12:07:40.613	org.eumetsat.hktv.ui.HTMLUserDisplayPanel	test user display.html: field PPTr1055 was not found		16	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
2019-11-11 12:07:40.708	org.eumetsat.hktv.ui.HTMLUserDisplayPanel	test user display.html: field CET00290 was		17	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
2019-11-11 12:07:40.711	org.eumetsat.hktv.ui.HTMLUserDisplayPanel	test_user_display.html: field PPETv127 was not found		18	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
2019-11-11 12:07:40.713	org.eumetsat.hktv.ui.HTMI.UserDisplayPanel	test user display.html: field PPETv111 was not found		19	2004-01-28 17:34:34.611	2019-11-11 12:	200.3
2019-11-11 12:07:40.776	org.eumetsat.hktv.ui.HTMLUserDisplayPanel	test user display.html: field @^IASING.tm.PUS.3.25		20	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:07:54.216	org.eumetsat.hktv.dataproc.lasiNgDataEnvelopeF	act IASI-NG data envelope factory initialised		21	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:07:54.217	org.eumetsat.hktv.AppBase	Stopping all data providers		22	2004-01-28 17:34:37.068	2019-11-11 12:	200.3
2019-11-11 12:07:54.217	org.eumetsat.hktv.AppBase	Adding data provider org.eumetsat.hktv.dataproc.ls		23	2004-01-28 17:32:01.457	2019-11-11 12:	200.3
2019-11-11 12:07:55.552	org.eumetsat.hktv.ui.DataRatePanel	too many packets with the same timestamp APID=9		24	2004-01-28 17:34:37.887	2019-11-11 12:	200.3
2019-11-11 12:07:55.562	org.eumetsat.hktv.ui.DataRatePanel	too many packets with the same timestamp APID=1		25	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:07:56.702	org.eumetsat.hktv.ui.DataRatePanel	too many packets with the same timestamp APID=9		26	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:07:56.703	org.eumetsat.hktv.ui.DataRatePanel	too many packets with the same timestamp APID=1		27	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:07:57.798	org.eumetsat.hktv.ui.DataRatePanel	too many packets with the same timestamp APID=1		28	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:07:58.846	org.eumetsat.hktv.ui.DataRatePanel	too many packets with the same timestamp APID=1		29	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:08:27.785	org.eumetsat.hktv.dataproc.lasiNgDataEnvelopeF	act IASI-NG data envelope factory initialised		= 30	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
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2019-11-11 12:08:27.787	org.eumetsat.hktv.AppBase	Adding data provider org.eumetsat.hktv.dataproc.ls		32	2004-01-28 17:34:35.430	2019-11-11 12:	200.3
2019-11-11 12:08:28.887	org.eumetsat.nktv.ul.SscverificationPanel	got SSC 66 where last SSC was 40 for NS IASING.tc.P		33	2004-01-28 17:34:35.430	2019-11-11 12	200.3
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993 2106 75	.928,677 15,415 4,392,084 4,723	989 5.985,102	6767 M	851	2019-11-11 12:08: 9.132	988	IASING.tc.PUS.S
994 132 5	.946,732 1,028 370,379 369	983 377,187		852	2019-11-11 12:08: 9.132	988	IASING.tc.PUS.9
995 1152 32	.819,904 10,536 2.398,275 2.763	636 3.494,322 OL		853	2019-11-11 12:08: 9.132	988	IASING.tc.PUS.
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Main window



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ayPanel	test_user_display.html:	field PPTr1	1039 was not found				15	2004-01-28 17:34:34.611	2019-11-11 12: 20	90.3	93	16	IASING.sd.PUS.200.3#ISY_MIS67010	36556	ODS science	7884
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ayPanel	test_user_display.html:	field CFT0	0290 was				17	2004-01-28 17:34:34.611	2019-11-11 12: 20	90.3	93	16	IASING.sd.PUS.200.3#ISY_MIS67010	36556	ODS science	7886
iyPanel	test_user_display.html:	field PPET	y127 was not found				18	2004-01-28 17:34:34.611	2019-11-11 12: 20	00.3 9	93	16	IASING.sd.PUS.200.3#ISY_MIS67010	36557	ODS science	7887
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taEnvelopeFact	IASI-NG data envelope	factory init	ialised				21	2004-01-28 17:34:35.430	2019-11-11 12: 20	00.3 9	98	67	IASING.sd.PUS.200.3#ISY_MIS67041	26166	ADA_MET_K	493
	Stopping all data provid	ders					22	2004-01-28 17:34:37.068	2019-11-11 12: 20	00.3 1	005	208	IASING.sd.PUS.200.3#ISY_MIS67001	9858	ADA_PROCE	585
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	too many packets with	the same t	imestamp APID=9				24	2004-01-28 17:34:37.887	2019-11-11 12: 20	0.3	005	208	IASING.Sd.PUS.200.3#IST_MIS67001	9858	ADA_PROCE	2000
	too many packets with	the same t	imestamp APID=1				25	2004-01-28 17:34:35.430	2019-11-11 12: 20	0.3	93	10	IASING.Sd.PUS.200.3#IST_MIS67010	33904	ODS science	7000
	too many packets with	the same t	imestamp APID=9				20	2004-01-28 17:34:35:430	2019-11-11 12: 20	0.3 9	95	16	IASING.sd.PUS.200.3#IST_MIS67010	30337	ODS science	7800
	too many packets with	the same t	imestamp APID=1				27	2004-01-28 17:24:25 420	2019-11-11 12: 20	0.5	95	16	IASING.SG.FUS.200.3#IST_MIS07010	26557	ODS science	7890
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-11 12:07	07:54.217	org.eumetsat.hktv.Ar	ppBase	Stor	oping all data provid	ders				22	2004-01-28 17:34	37.068 20	019-11-11 12:	200.3	1005
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1-11 12:07	7:58.846	org.eumetsat.hktv.ui	DataRatePanel	too	many packets with	the same timestamp /	APID=1			29	2004-01-28 17:34	35.430 20	J19-11-11 12:	200.3	993
-11-11 12:08	18:27.785	org.eumetsat.hktv.da	ataproc.lasiNgData	EnvelopeFact IASI-	-NG data envelope	factory initialised				30	2004-01-28 17:34	35.430 20	019-11-11 12:	200.3	993
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HKTV core components



- DataProvider pushes packets into the system
- **PacketSaver** saves received packets
- PacketFormatDetector detects packet format
- StreamConsistencyChecker checks input stream (e.g. OBT or SSC jumps)
- TimeCorrelation OBT <-> Java time
- **Archive** stores data
- **Automation** infrastructure to run scripts
- LimitsChecker
- **SynopticsDisplay** (e.g. redundancies switch)
- **TimeSeriesDisplay** (e.g. for temperatures)



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Input data providers



HKTV implements a bunch of input data providers. As HKTV message bus requires data packets on input, some preprocessing is usually required to extract/generate the packet from the input data. Supported data sources:

- Local files with CCSDS packets, CADU stream, MMFU SCOE dumps, UDMS dumps, IRIG dumps, etc.
- Remote TCP connection (incoming/outgoing): CCSDS packet with some optional headers
- Data loading from CCS5 MySQL database

Data loaders are light-weight components (100-200 lines) extracting the data from the input source and putting onto the bus, so it's very easy to add a new one.

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Data savers



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HKTV supports several output data formats:

- proprietary HKP-2 format (portable house-keeping data format)
- MHS SD archive data format
- CCSDS packet stream
- Easily extensible to add other data formats

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Packet format detector



Default implementation determines packet format based on PUS service/subservice and fixed values as specified in the MIB database.

Tailored mission-specific implementations can be provided overriding the virtual method (e.g. for performance reasons).



Archive



HKTV implements archive in MongoDB.

The archive stores:

- opaque data (bytestream of CCSDS packets received)
- decomposed data (each mnemonic stored separately: high resources need!)

What exactly is stored is configurable: opaque packets, CCSDS packet headers, serialized packets, decomposed packets (individual parameters).



Automation



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HKTV implements automation in Groovy language.

From the Groovy environment access is granted to all HKTV components.

Groovy execution is mirrored line-by-line into as-run report.

Example to load a set of CADU files:

```
logger.info("starting CADUs data feed")
x = new CaduStreamDataProvider()
app.setDataProvider(x)
path = "/data/REC_2019_09_13_14_11_59_TMRATE_FORMAL_RUN_SMDA/"
x.loadCadu(new File(path + "0.dat"))
x.loadCadu(new File(path + "1.dat"))
x.loadCadu(new File(path + "2.dat"))
x.loadCadu(new File(path + "3.dat"))
logger.info("CADU data feed finished")
```

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Synoptics displays



HKTV supports synoptics displays specified in SVG or HTML.

The displays receive the full data feed, including parameter status. JavaScript is used for additional data processing, special effects, etc.



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Limits checking



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Fully SCOS2000 compatible.

In addition, different limit sets can be chosen (e.g. for ambient, thermal vacuum, etc.)

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Data fetching concept



Each monitoring parameter is represented internally in <u>DataField</u> class: can be <u>PhysicalDataField</u> or <u>SyntheticDataField</u>.

To retrieve data, a Fetcher shall be obtained using DataField.getFetcher(). Normally it is a <u>BitStreamFetcher</u>. A fetcher is a highly-optimized class going directly into bit stream and getting the necessary piece of data.

But it's also flexible due to a proxying approach, e.g.

- <u>PatchableFetcher</u>(Fetcher): real-time data patching
- <u>ConditionalFetcher</u>(Fetcher): conditional field
- <u>EnumFetcher</u>(Fetcher): fetch number and apply textual calibration

And this is absolutely transparent to the users.



Performance



Performance depends on the deployment configuration, e.g. archive options, plotting options, synoptic displays, etc.

Reference configuration loading Metop-SG CADU stream processes >5000 CCSDS packets per second on a 14-core Mac Pro (Xeon 2.5GHz). Deployment options: no archive, 4 plots, no synoptic displays.

Switching on MongoDB archive on local machine reduces performance by ~30-90% depending on settings (proprietary HKTV archive has no performance impact).

Build time (gradle): ~2 minutes.

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Performance



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HKTV memory footprint:

- 15000 IASI-NG packets: 1.3GB
- 365000 MetOp-SG packets: 5.6GB

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Each data consumer runs in a separate thread. Thus performance on a single machine is limited by the number of cores.

The slowest data consumer defines the length of backlog, since packets have to be kept in memory as long as they have not been processed.

It is possible to connect to the message bus remotely via TCP, thus some processing can be made on a remote machine.

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Mission database



MDB is represented by a set of XML files and includes definitions of:

- TM, TC and Science data packets description
- Transfer functions definitions
- Limits definitions
- Plots definitions
- User displays definitions
- Reporting can also be customized, but functioning defaults are provided



Tailoring to a new mission



Tailoring means:

- Creation of a new application class (inherit from AppBase and implement abstract methods), tailor creation of windows and menus
- Provision of mission database (manual or automatic conversion; convertors from SCOS MIB, RangeDB XLS and EGS-CC CDM are available)
- Cosmetic: background, logo, etc.

If needed: implementation of instrument-specific data processing

HKTV in action

EUMETSAT CSa

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VVMs Of Koffman

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MHS bench:

- 2 DELL laptops
- 2 monitors
- 2 Cisco switches
- 1 printer

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HKTV in action



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MHS bench:

- 2 DELL laptops
- 2 monitors
- 2 Cisco switches
- 1 printer



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HKTV in action



IASI-NG bench:

- Mac Pro
- Cisco switch
- CCS5 simulator (2 Raspberry Pls)



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Looking back



- Java proved to be the right choice due to its API stability and multiplatform support. HKTV required almost no adaptation moving from Java 5 to Java 13.
- Java Swing proved to be the right choice for UI. Other technology, e.g. SWT, JavaFX or Web-based have not remained that stable over 10 years and would have required significant adaptations.
- Monolithic application is appropriate for such project (~50K LOC). Clean package and component separation is essential. Other approaches e.g. OSGi or service based would have often required reengineering and adaptations.
- Data bus concept proved to be extremely flexible and extensible. Numerous data sources and consumers added without any changes being necessary.
- Build system migrated from ant to gradle: minor change.

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