

ESAW 2017

Architecting a massive satellite constellation ground system

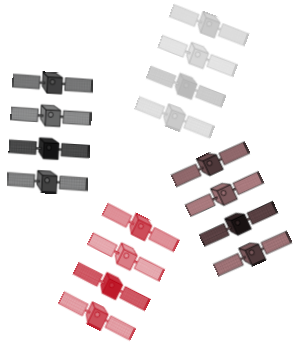


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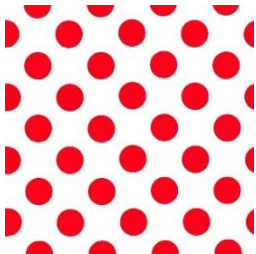
HIGHLIGHTS



GMV is developing a Command and Control system for a 1000+ LEO telecom satellite fleet

The system is based on ***hifly***, the GMV suite of COTS for satellite fleet monitoring and control

hifly



hifly will be left largely unmodified, adaptations for: massive fleet support:

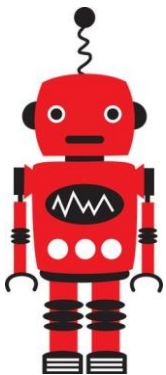
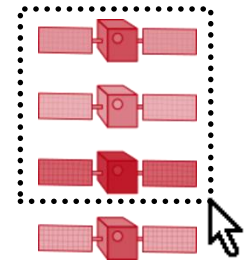
- Downsizing
- Fleet HMIs (groups of satellites)
- Massive fleets awareness (***fleetDashboard***)

HIGHLIGHTS



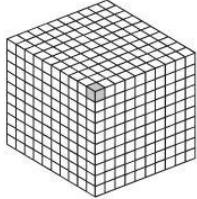
Satellites are ECSS PUS compliant:
supported by **hifly** out-of-the-box

Grouping of satellites is essential:
changing an out-of-limits definition for a
set of satellites at the same time...



Nominal operations can be fully
automated; (known) anomaly recovery
will also be automated as mission evolves

HIGHLIGHTS



The deployment model is very simple:

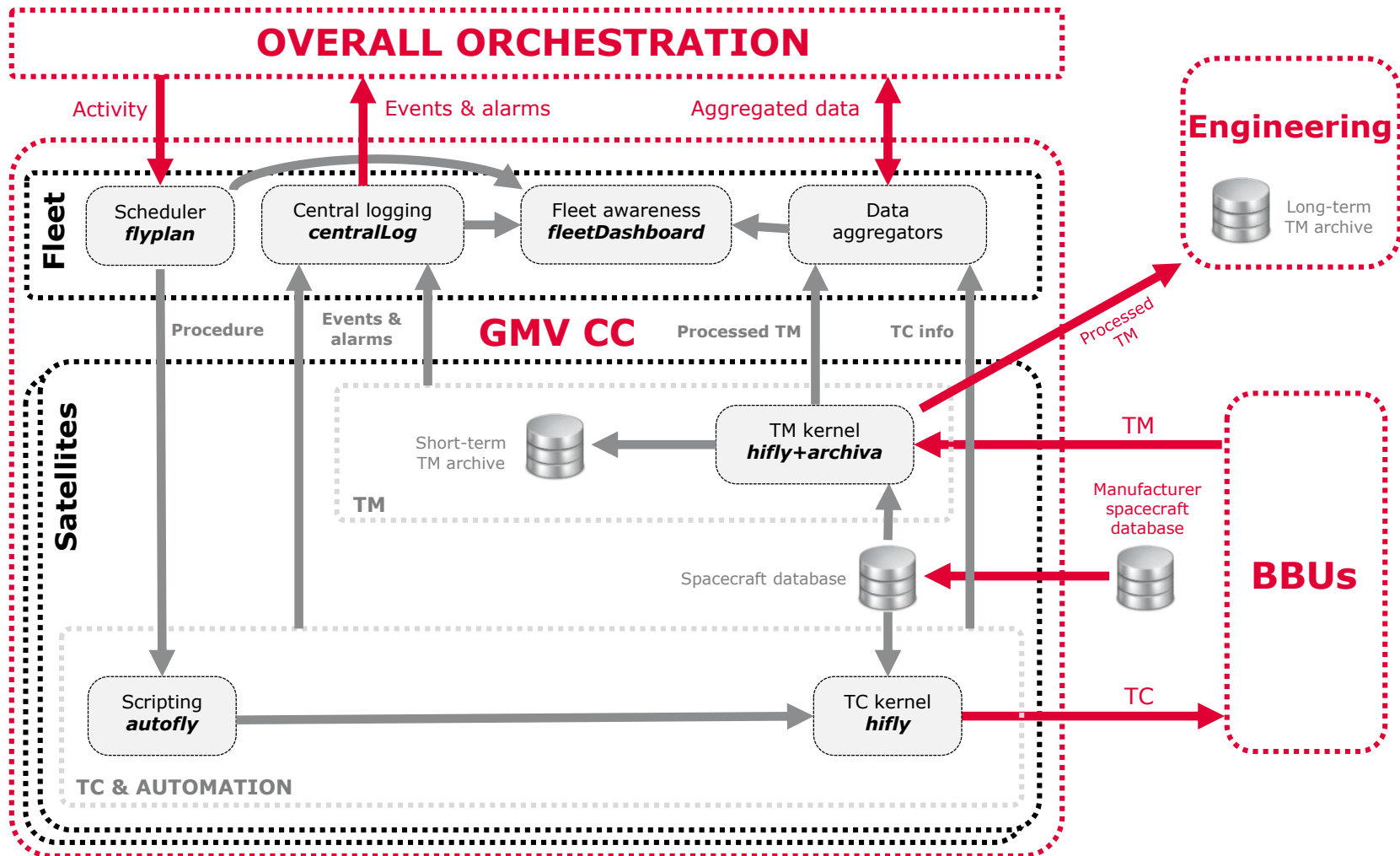
- One (redundant) **hifly** core instance per satellite
- One (redundant) set of fleet tools for the complete fleet

Aimed for real-time operations: the archive is short-term (say 1 month): processed TM is forwarded to engineering for long-term archive



The Command and Control system features many interfaces, particularly for overall orchestration of the fleet operations

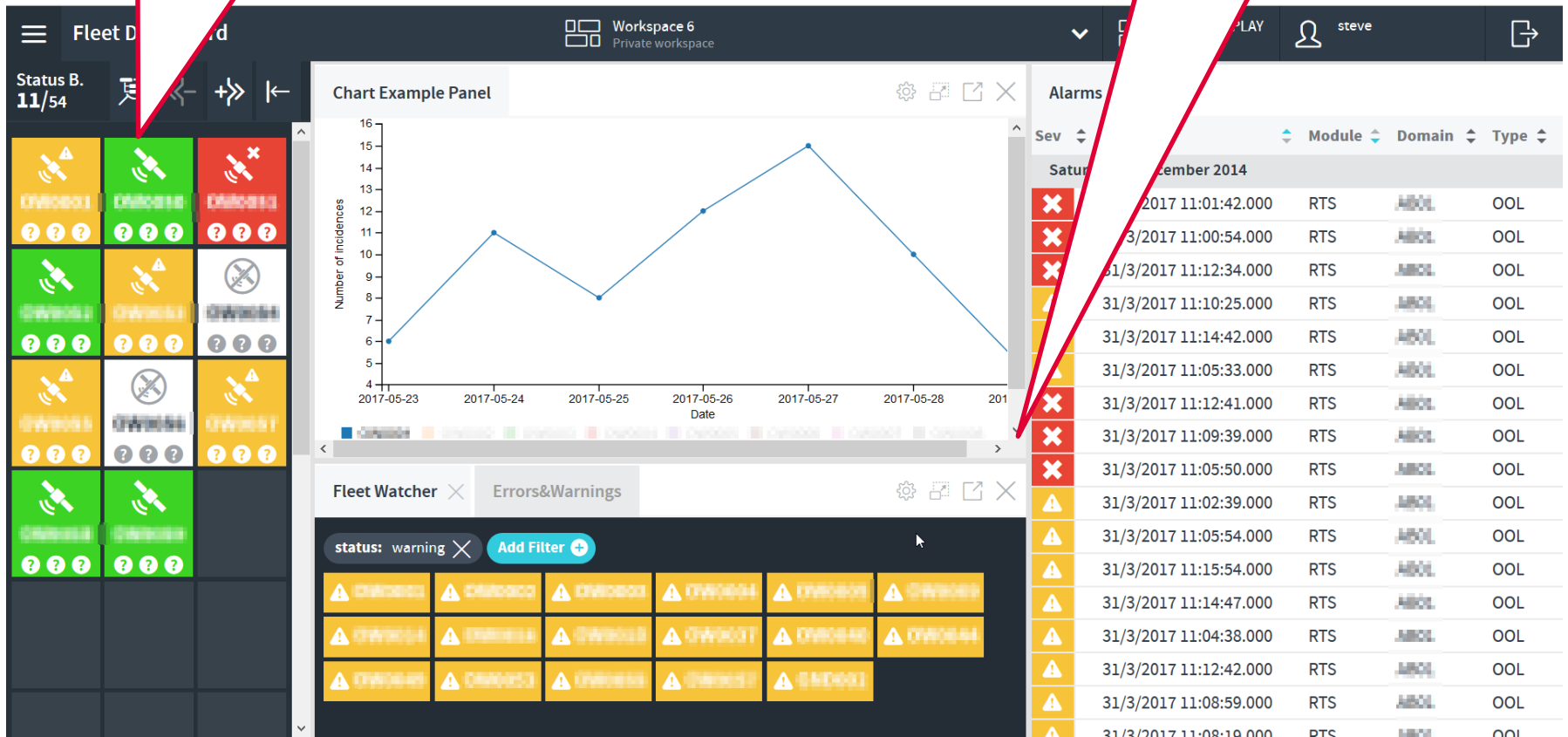
ARCHITECTURE



FLEET AWARENESS – STATUS BOARD

Status board: subset of satellites in the fleet

Panels: data about the subset of satellites in the status board



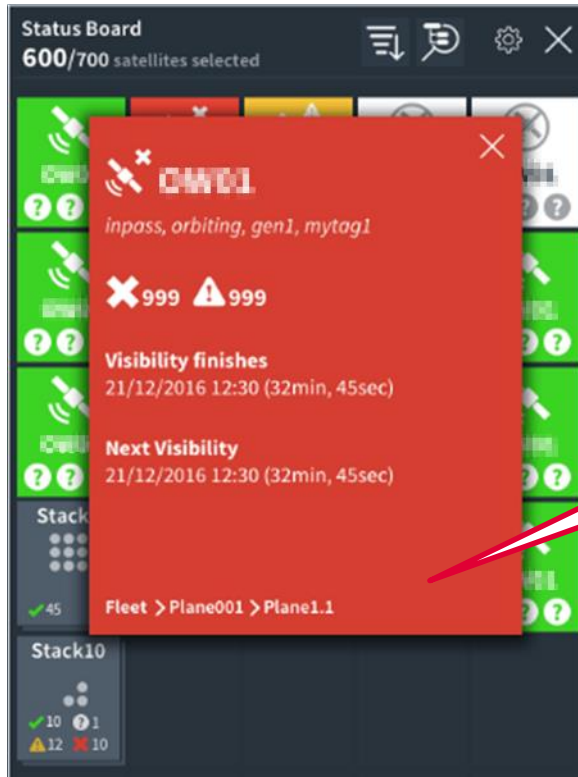
FLEET AWARENESS – STATUS BOARD



Cards are individual satellites...

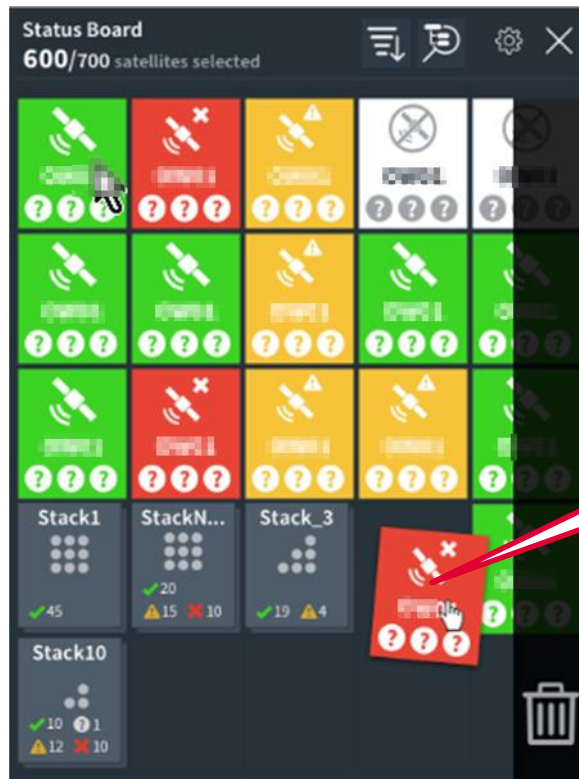
...and can be stacked

FLEET AWARENESS – STATUS BOARD



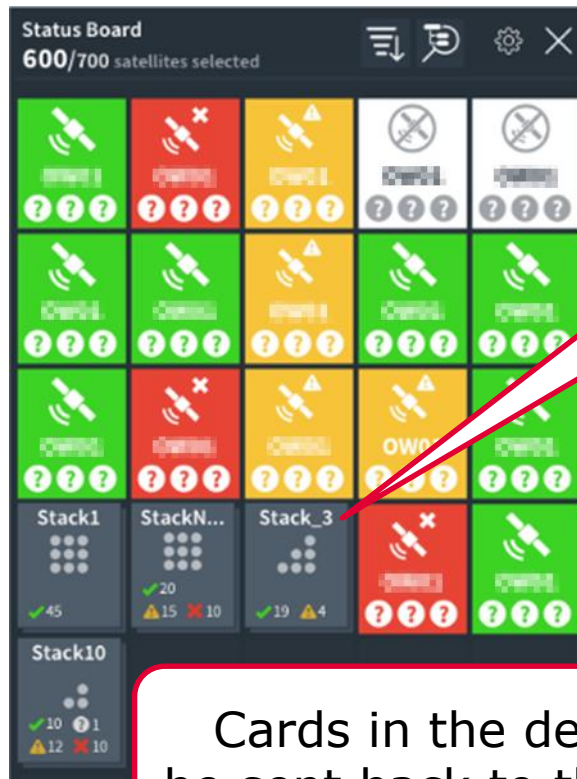
Cards can be flipped for further information

FLEET AWARENESS – STATUS BOARD



Cards can be dragged onto the trash bin

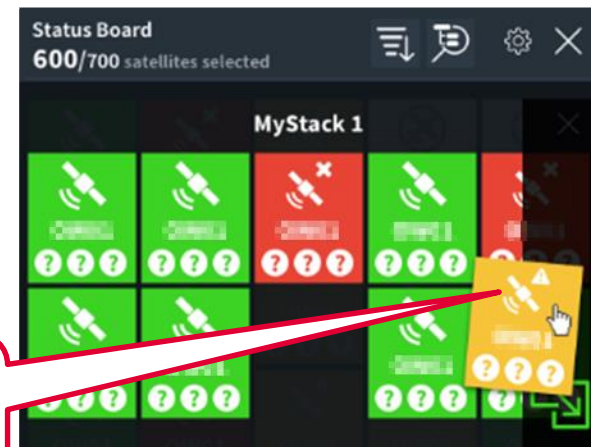
FLEET AWARENESS – STATUS BOARD



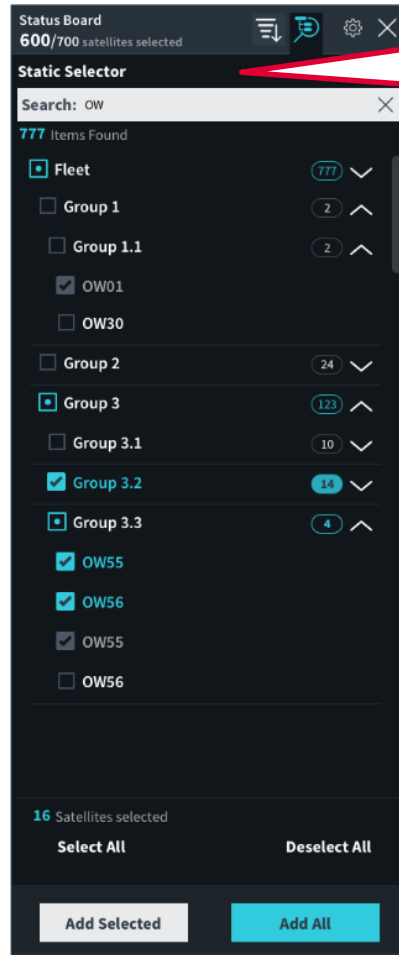
Acting upon a card deck...

...expands the deck

Cards in the deck can be sent back to the board

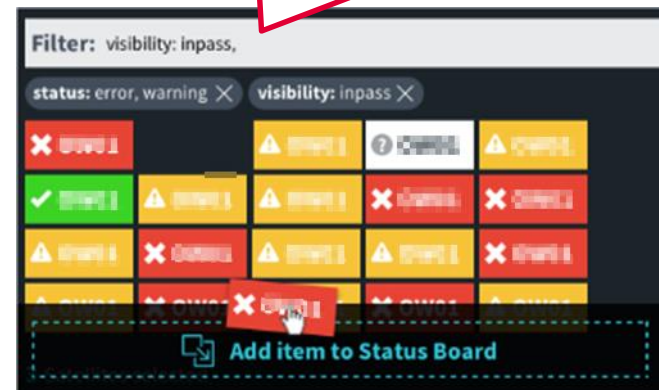


FLEET AWARENESS – STATUS BOARD



Satellites can be added to the board with a static selector...

... or with a dynamic one ("show satellites in pass")



FLEET AWARENESS – PANELS

Spreadsheet panel: satellite and aggregated telemetry

A_ST_AQ2									
	A	B	C	D	E	F	G	H	I
1	ASW_1395	0.0000000 lts	ASWae_Ltotal_X	ASW_3395	00.00.00		ASWae_Ltotal_X	ASW_3395	837
2	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	191
3	ASW_1395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	368
4	ASW_3395	-453600010 ms	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	193
5	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000	#PSY_028X#2	1	ASW_3395	305
6	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000	#PI.name	#PI.raw_value	ASW_3395	724
7	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000	Text	ASWsc_RW_Mom_val	ASW_3395	65
8	ASW_3395	1000001000	ASWae_Ltotal_X	DIFF_TIME	44456776676		ASWae_Ltotal_X	ASW_3395	283
9	ASW_3395	Not Active	ASWae_Ltotal_X	ASW_3395	Not Active		ASWae_Ltotal_X	ASW_3395	712
10	ASW_1395	Not Active	ASWae_Ltotal_X	ASW_3395	Not Active		ASWae_Ltotal_X	ASW_3395	288
11	ASW_3395	0.0000000	ASWae_Ltotal_X	ASW_3395	Not Active		ASWae_Ltotal_X	ASW_3395	849
12	ASW_1395	330000	ASWae_Ltotal_X	ASW_3395	Not Active		ASWae_Ltotal_X	ASW_3395	459
13	ASW_3395	00.00.00	ASW_2775	0.0000000000 ms					
14	ASW_3395	01 kg	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	979
15	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	536
16	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395			ASWae_Ltotal_X	ASW_3395	761
17	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	ASWae_Ltotal_X		ASWae_Ltotal_X	ASW_3395	141
18	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	828
19	ASW_1395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	385
20	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	938
21	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	326
22	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	245
23	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	30
24	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	118
25	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	470
26	ASW_3395	00.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	115
27	ASW_3395	0.00000	ASWae_Ltotal_X	ASW_3395	0.000.000		ASWae_Ltotal_X	ASW_3395	530

Cell Parameters

Rules

- 001 Parameter_Name Value bigger than: 999000999
- 001 Parameter_Name Value lower than: 999000999

Add new rule

Parameters

Actual Parameter

Name	DIFF_TIME
Description	Su deler esseva pan, unic human conferentias tu uno.
Units	milliseconds

Parameters Library

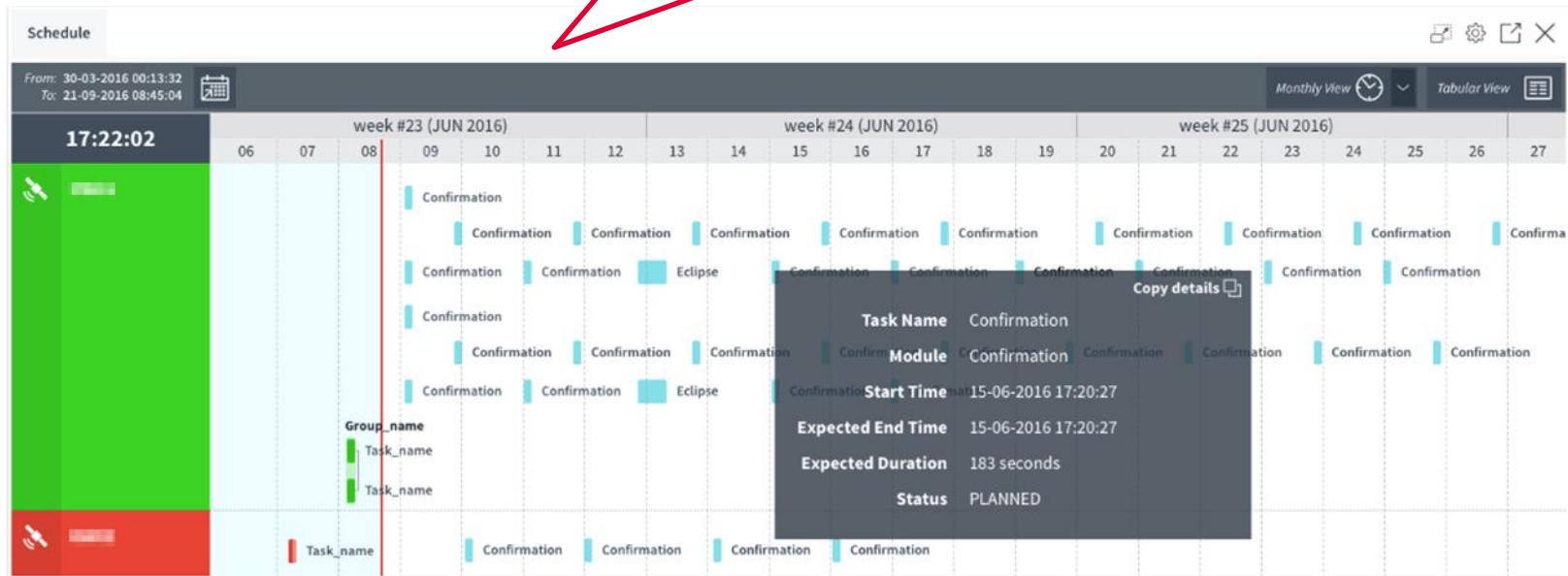
Name	Description	Units
DIFF_TIME	Diff time OBT-GROU...	milsec
DIFF_TIME2	Diff time OBT-GROU...	milsec
DIFF_TIME3	Diff time OBT-GROU...	milsec
DIFF_TIME4	Diff time OBT-GROU...	milsec

filter: DIFF_T

Add new Parameter

FLEET AWARENESS – PANELS

Scheduler panel: satellite operations Gantt chart



FLEET AWARENESS – PANELS

Events & alarms panel

Errors and Warnings							
Sev	ACK	Time	Site	Module	Domain	Type	Description
Tuesday 26 January 2016							
✖	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
⚠	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
⚠	✅	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
✖	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
✖	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
⚠	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
⚠	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
⚠	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
Monday 25 January 2016							
⚠	✅	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
✖	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
✖	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error
⚠	🔊	26/01/2016 09:22:31.000	GMV	RTS		M	[ARI134]ODBC error

CONCLUSIONS

- With such a massive fleet, the CONOPS shall focus on the fleet rather than individual satellites (*each satellite may be dispensable*)
- Virtualization and robust COTS such as **hifly** enables massive scaling
- Unattended operations: do not bother the human team until a (new) anomaly arises
- Effective Dashboard. More than 1000 satellites at a glance
- Flexible grouping/filtering/selection. Drill down the fleet to the satellites you want
- Lessons learnt still to come!!



Thank you

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