

Architecting OneWeb's Massive Satellite Constellation Ground System

GROUND SEGMENT ARCHITECTURE WORKSHOP 2017



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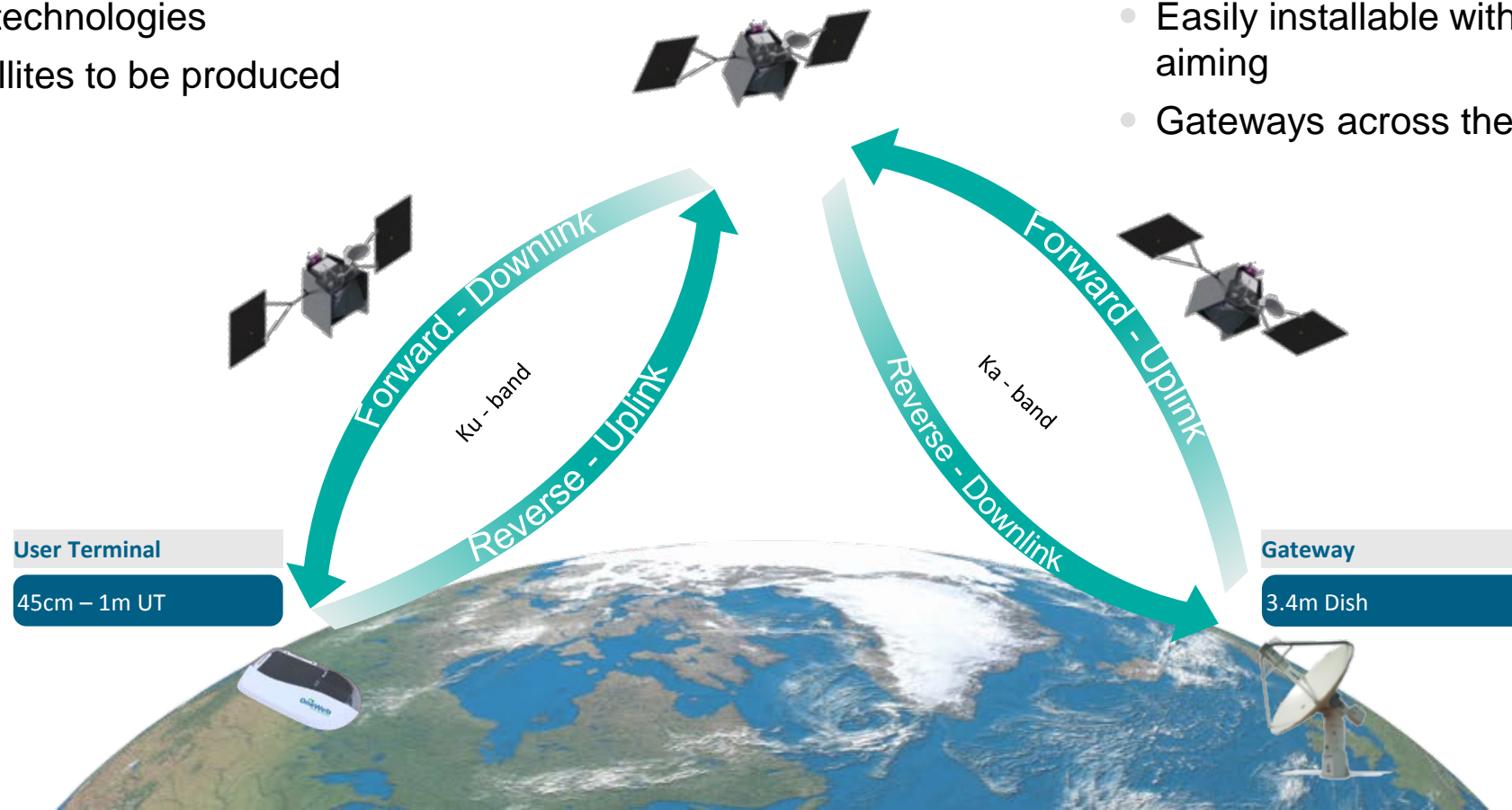
OneWeb System Overview

Constellation

- Innovative beam technology
- Small, inexpensive satellites using existing technologies
- 900 satellites to be produced

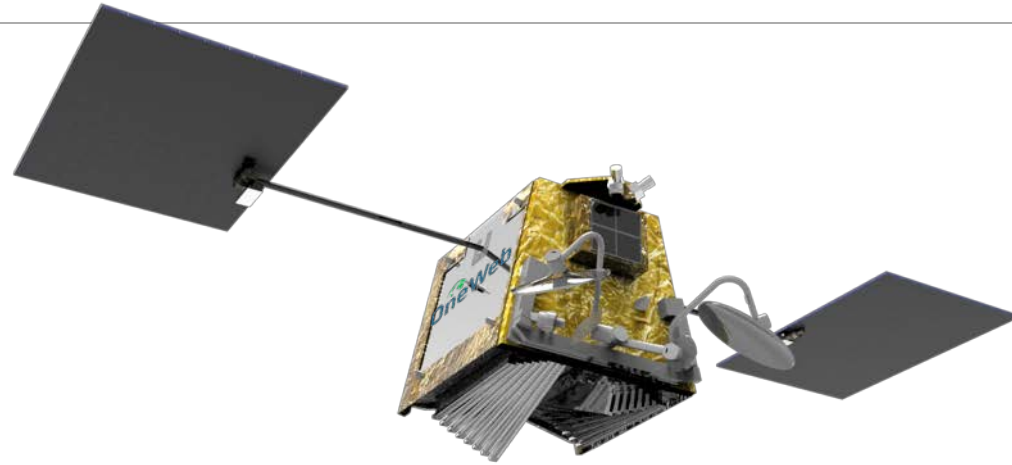
Ground

- Affordable, compact, multi-user access terminals
- Easily installable without position aiming
- Gateways across the globe



Low-Cost, Mass-Produced Satellites

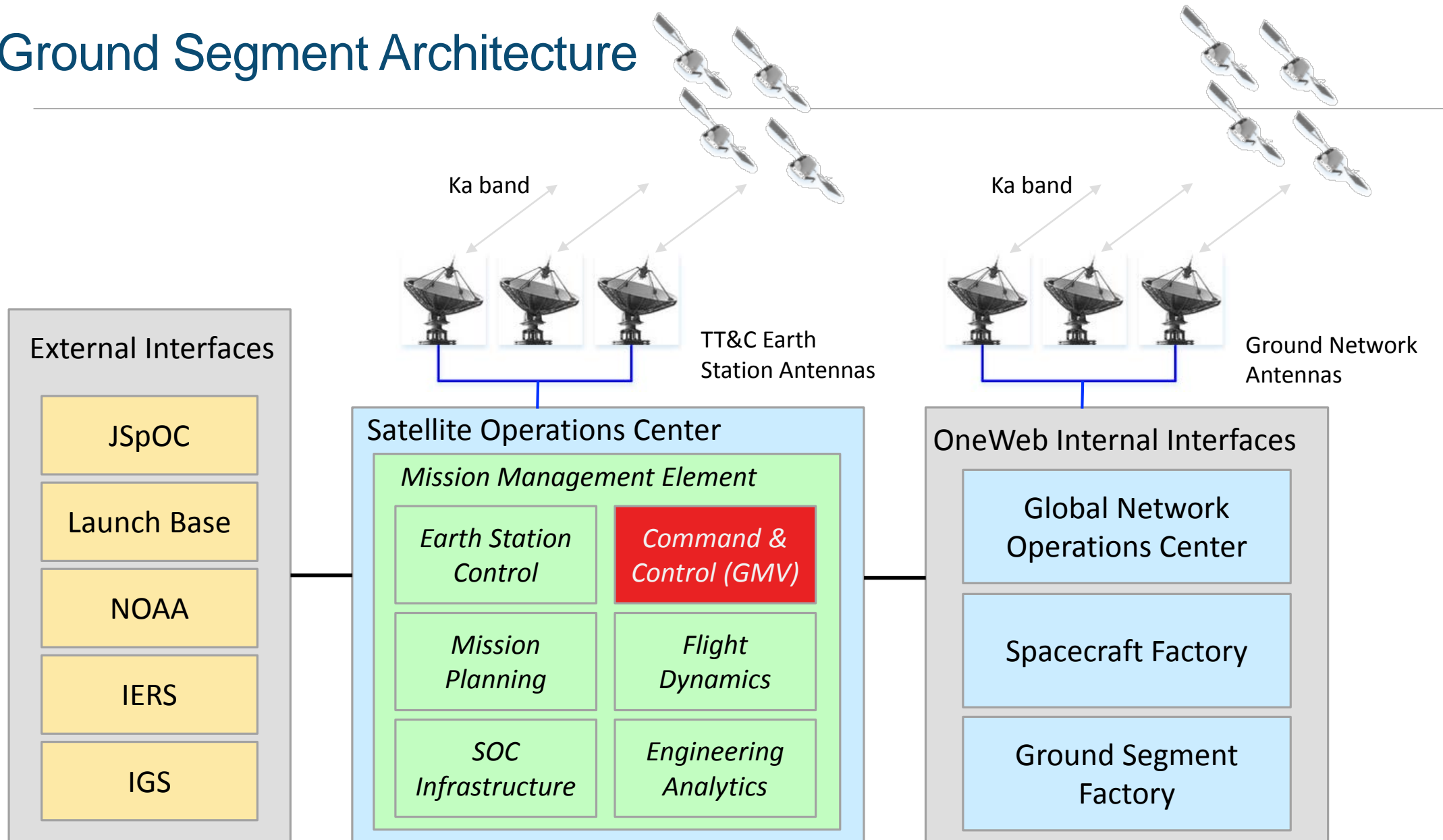
- Small, low mass satellites with modular design
- Produced in new manufacturing facility for high-rate and low-cost production
- Leverages existing and proven technology
- Unique modular design
- Strong industry participation



All Major Systems Designed

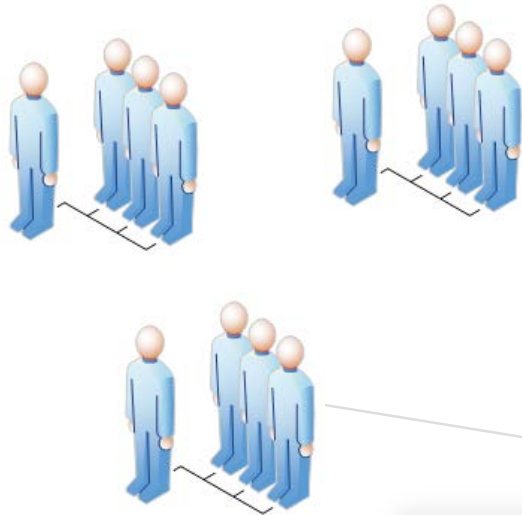
- Electric Propulsion
- Thermal Control
- Electrical Power
- Avionics and TT&C
- User Antenna
- Gateway Antenna
- Mechanical Systems
- Guidance, Navigation and Control

Ground Segment Architecture

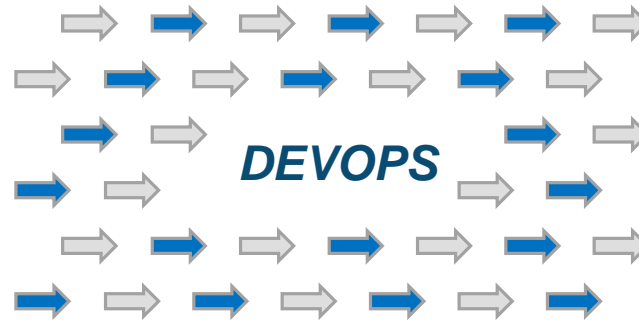


Distributed Engineering Using Proven COTS Software

Development Teams



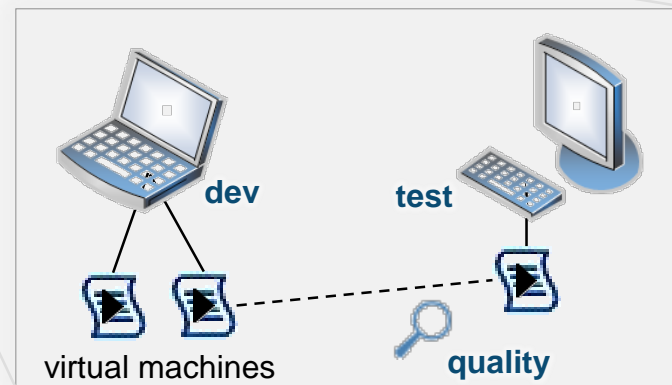
Software Releases



OneWeb DevLab

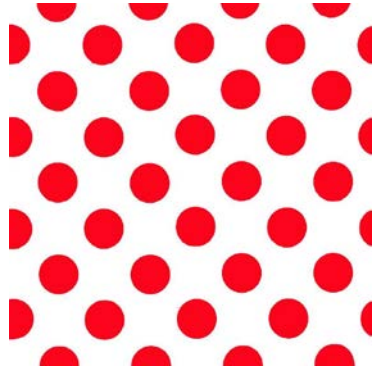


periodic integration



continuous integration

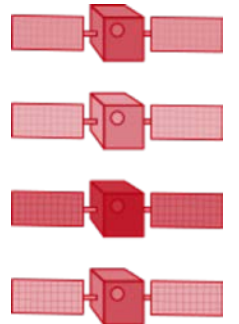
The CCE is based on *hifly*, the GMV suite of COTS for satellite fleet monitoring and control



hifly largely unmodified, adaptations for: massive fleet support:

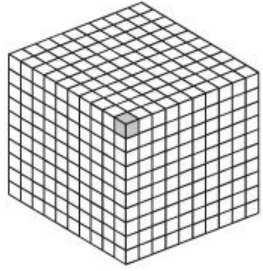
- Downsizing
- Fleet HMIs (groups of satellites)
- Massive fleets awareness (*fleetDashboard*)

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



The satellites are CCSDS compliant: supported by *hifly* out-of-the-box





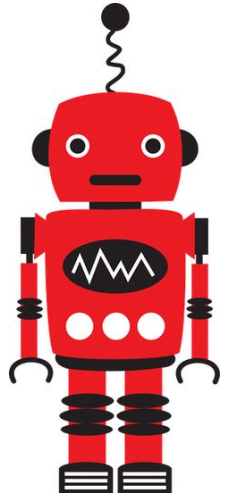
The deployment model is very simple:

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

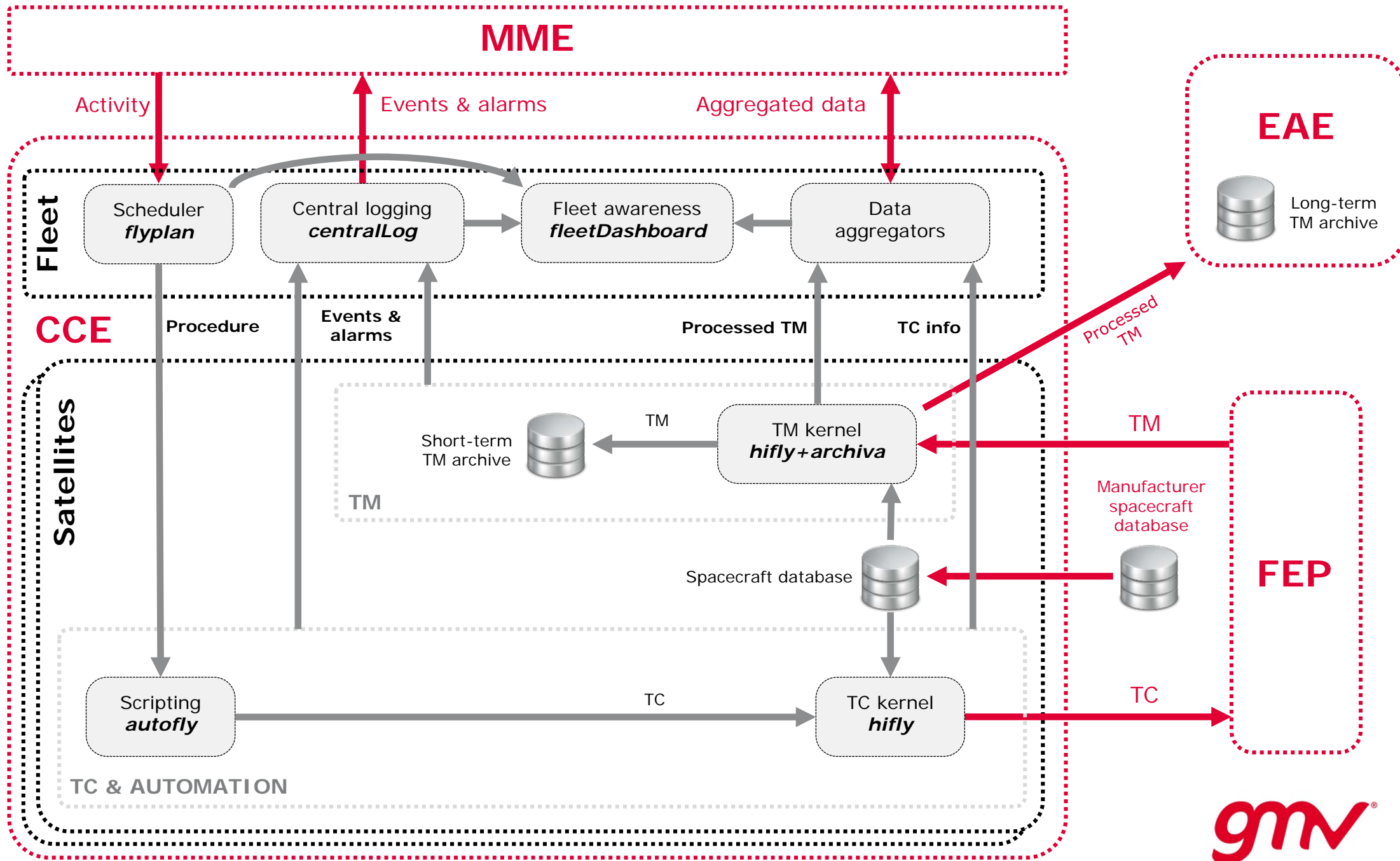
Nominal operations are fully automated;
(known) anomaly recovery will also be automated as mission evolves



CCE is aimed for real-time operations: its archive is short-term only (say 1 month). Processed TM is forwarded to Engineering Analytics for long-term archive



ONEWEB GROUND - CCE ARCHITECTURE



ONEWEB GROUND - CCE FLEET AWARENESS

The screenshot displays the 'Fleet Display' interface. At the top, there is a navigation bar with 'Fleet Display' in the center, and 'NEW DISPLAY', 'RESET LAYOUT', and 'Admin Name (ADMIN)' on the right. The main content area is divided into several panels:

- Status Board:** A grid of satellite status indicators. The top row shows '600/700 satellites selected'. Below it, there are rows of satellite icons labeled 'OW01' and 'Stack1'. Some icons are green (OK), some are red with an 'X' (Error), and some are yellow with a triangle (Warning). Each icon has a small circular indicator below it with a question mark.
- Schedule:** A large empty panel on the right side of the top row.
- Errors and Warnings:** A panel below the Status Board, containing sub-sections for 'Alarms' and 'Events'.
- Summary:** A panel on the right side of the bottom row.

Two callout boxes provide additional context:

- A red-bordered box on the right side of the Status Board contains the text: "Panels: data about the subset of satellites in the status board".
- A white-bordered box with a red border and a pointer pointing to the Status Board contains the text: "Status board: subset of satellites in the fleet".

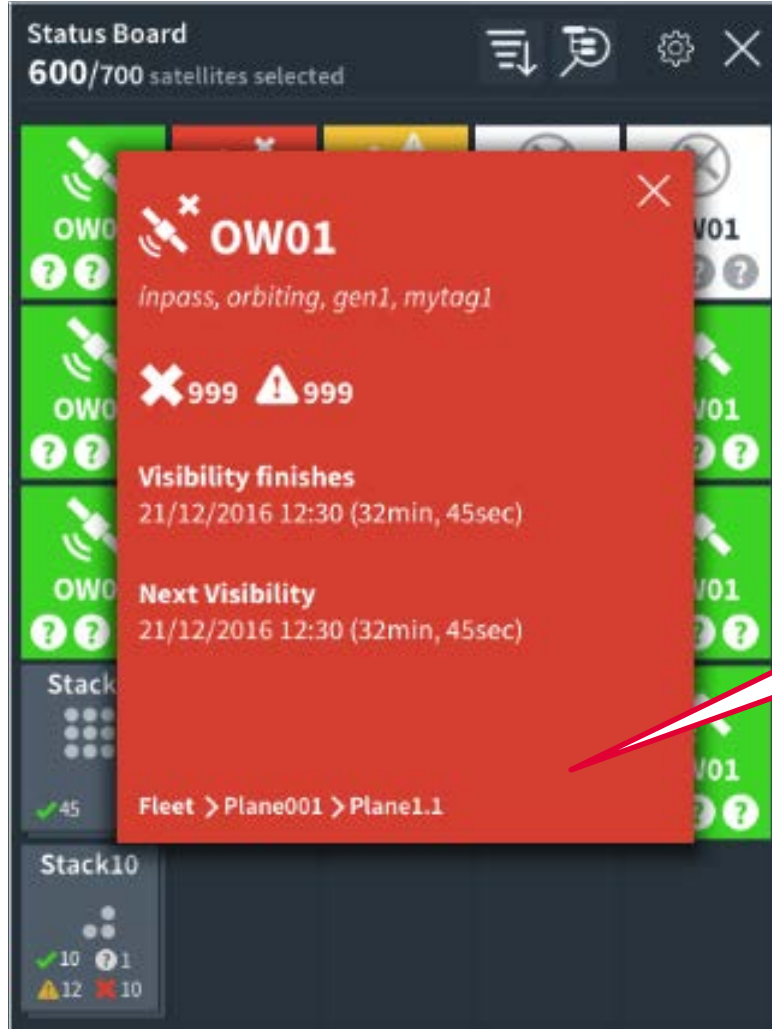
ONEWEB GROUND - CCE STATUS BOARD



Cards are individual satellites...

...and can be stacked

ONEWEB GROUND - CCE STATUS BOARD



Cards can be flipped for further information

ONEWEB GROUND - CCE STATUS BOARD



Cards can be dragged onto the trash bin

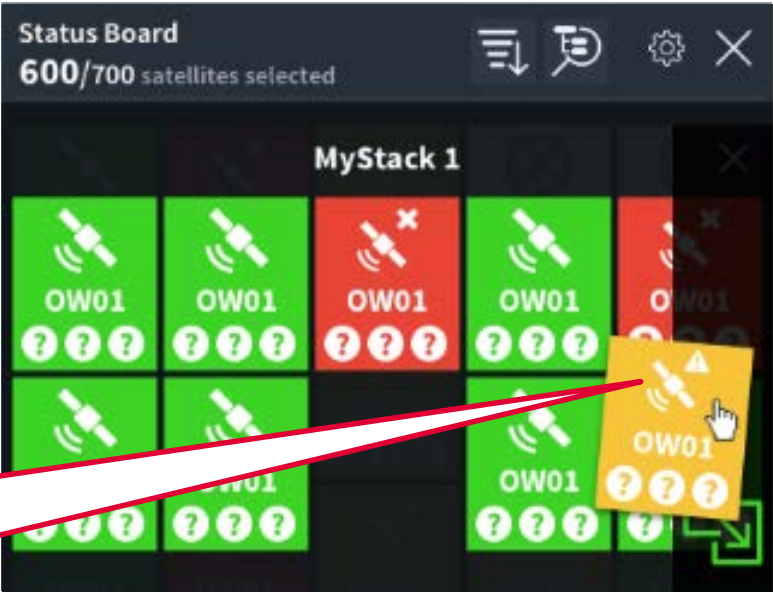
ONEWEB GROUND - CCE STATUS BOARD



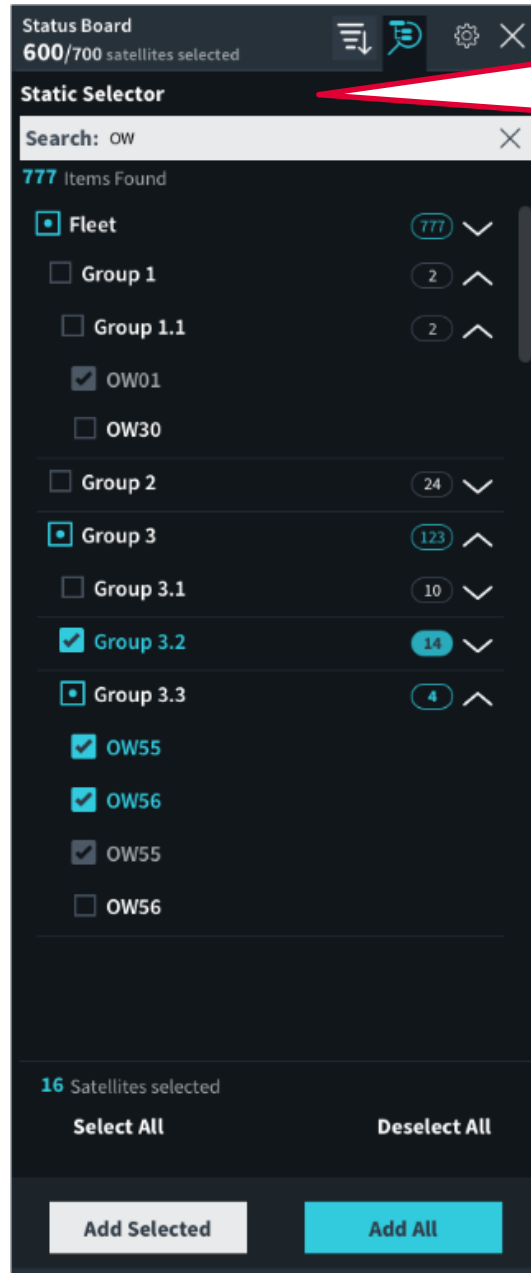
Acting upon a card deck...

...expands the deck

Cards in the deck can be sent back to the board

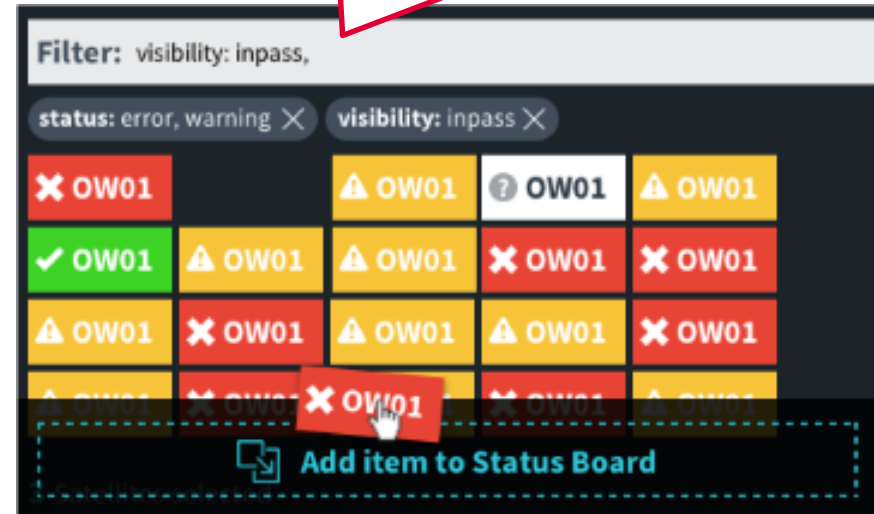


ONEWEB GROUND - CCE STATUS BOARD



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

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



ONEWEB GROUND - CCE PANELS

Spreadsheet panel: satellite and aggregated telemetry

The screenshot displays a spreadsheet interface with the following data:

	A	B	C	D	E	F	G	H	I
1	ASW_335S	0.0000000 lts	ASWae_Ltotal_X	ASW_335S	00.00.00		ASWae_Ltotal_X	ASW_335S	837
2	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	191
3	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	368
4	ASW_335S	-453600010 ms	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	193
5	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000	#PSY_028X#2	1	ASW_335S	305
6	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000	=P1.name	=P1.raw_value	ASW_335S	724
7	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000	Text	ASWsc_RW_Mom_val	ASW_335S	65
8	ASW_335S	100001000	ASWae_Ltotal_X	DIFF_TIME	44456776676		ASWae_Ltotal_X	ASW_335S	283
9	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	Not Active		ASWae_Ltotal_X	ASW_335S	712
10	ASW_335S	Not Active	ASWae_Ltotal_X	ASW_335S	Not Active		ASWae_Ltotal_X	ASW_335S	288
11	ASW_335S	0.0000000	ASWae_Ltotal_X	ASW_335S	Not Active		ASWae_Ltotal_X	ASW_335S	849
12	ASW_335S	330000	ASWae_Ltotal_X	ASW_335S	Not Active		ASWae_Ltotal_X	ASW_335S	459
13	ASW_335S	00.00.00	ASW_277S	0.000000000 ms					
14	ASW_335S	01 kg	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	979
15	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	536
16	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	ASWae_Ltotal_X		ASWae_Ltotal_X	ASW_335S	761
17	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	ASWae_Ltotal_X		ASWae_Ltotal_X	ASW_335S	141
18	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	828
19	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	385
20	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	938
21	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	326
22	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	245
23	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	30
24	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	118
25	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	470
26	ASW_335S	00.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	115
27	ASW_335S	0.00000	ASWae_Ltotal_X	ASW_335S	0.000.000		ASWae_Ltotal_X	ASW_335S	530

The 'Cell Parameters' panel on the right contains the following sections:

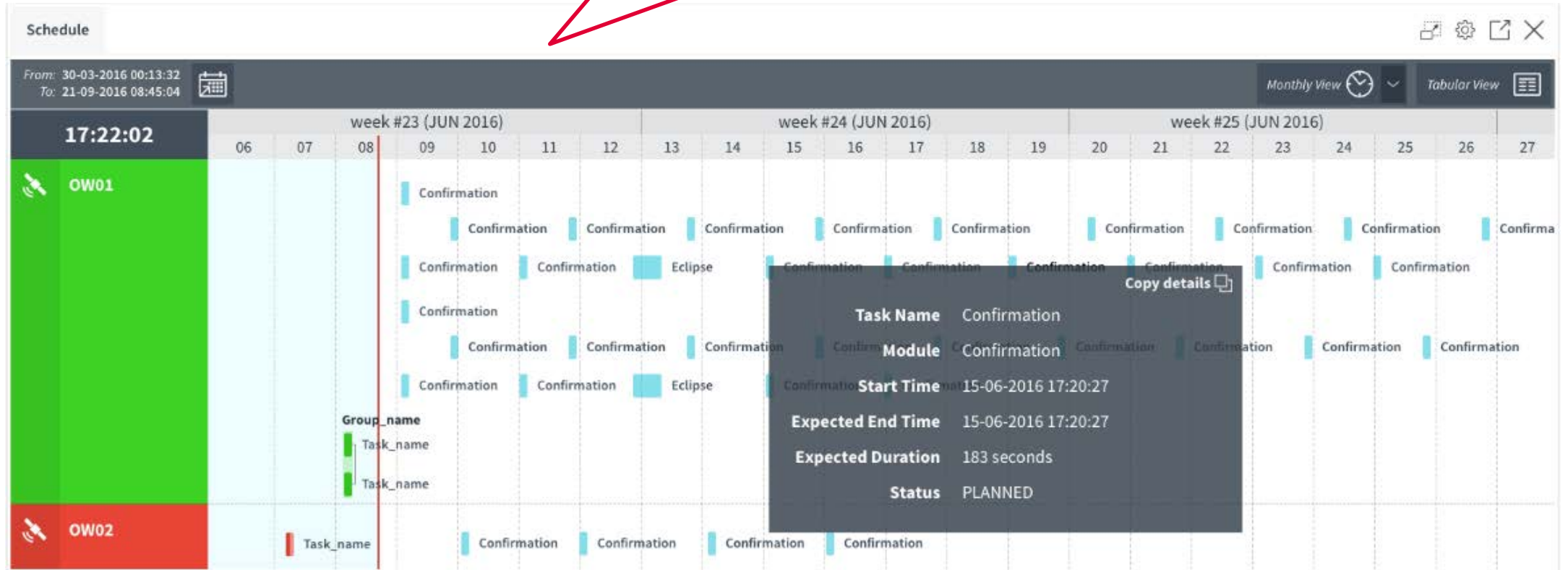
- Rules:**
 - 001 Parameter_Name Value bigger than: 999000999
 - 001 Parameter_Name Value lower than: 999000999
- Parameters:**
 - Actual Parameter:**
 - Name: DIFF_TIME
 - Description: Su deler esseva pan, unic human conferentias tu uno.
 - Units: milliseconds
- Parameters Library:**

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



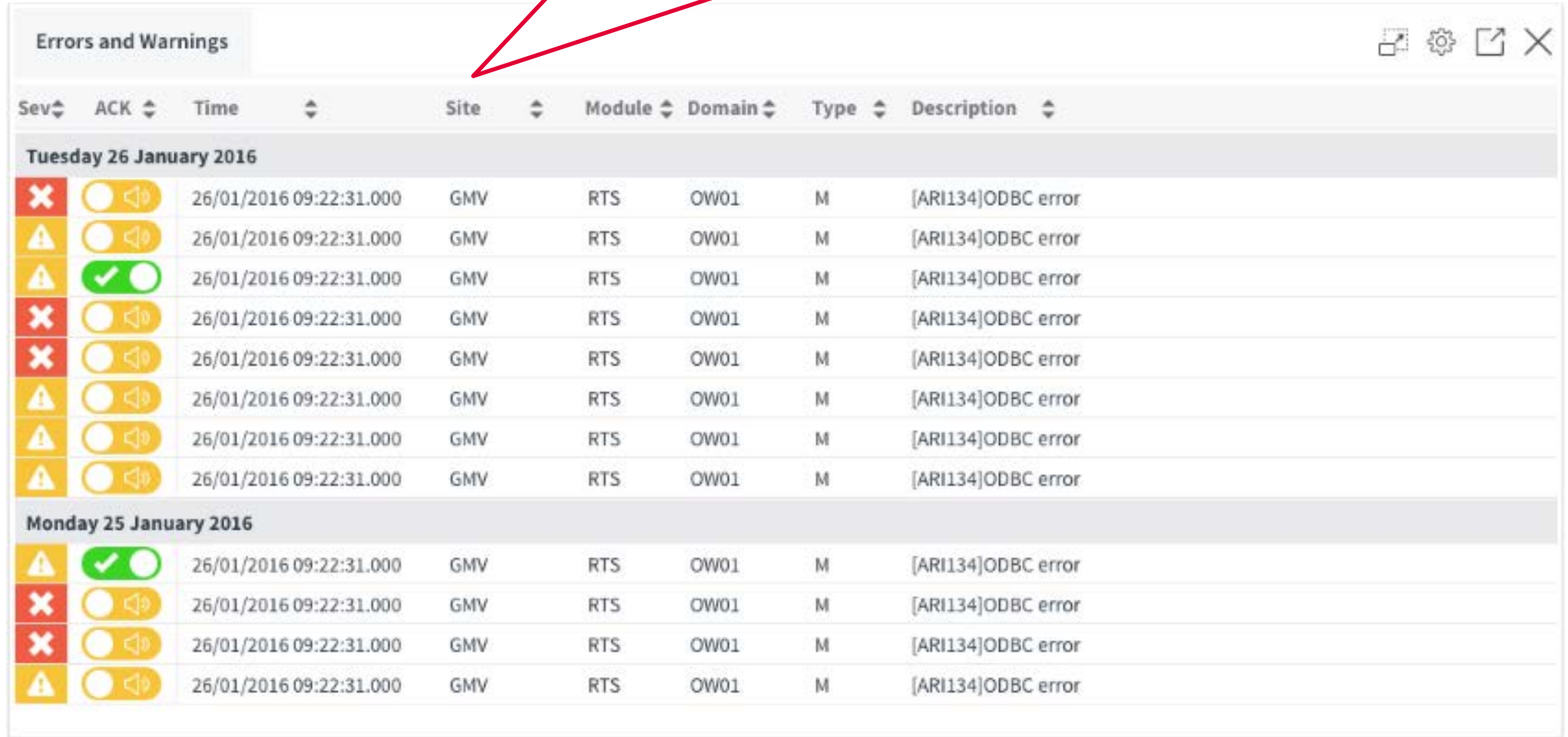
ONEWEB GROUND - CCE PANELS

Scheduler panel: satellite operations Gantt chart



ONEWEB GROUND - CCE PANELS

Events & alarms panel: satellite
Operations Gantt chart



The screenshot displays the 'Errors and Warnings' panel with a table of events. The table has columns for Severity (Sev), Acknowledgment (ACK), Time, Site, Module, Domain, Type, and Description. The data is grouped by date, showing events for Tuesday 26 January 2016 and Monday 25 January 2016. Each row includes a severity icon (red X for error, yellow triangle for warning), an acknowledgment icon (yellow bell for unacknowledged, green checkmark for acknowledged), and a time stamp.

Sev	ACK	Time	Site	Module	Domain	Type	Description
Tuesday 26 January 2016							
X	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
⚠️	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
⚠️	✅	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
X	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
X	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
⚠️	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
⚠️	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
⚠️	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
Monday 25 January 2016							
⚠️	✅	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
X	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
X	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error
⚠️	🔔	26/01/2016 09:22:31.000	GMV	RTS	OW01	M	[ARI134]ODBC error

Technology and Fleet-Focused ConOps Enable Massive Scaling

- Many technical challenges remain due to the shear scale of our mission
- Innovation and focus on **operating the fleet** drives our Concept of Operations
- Low risk core components such as Hifly enable this shift in thinking
- Take advantage of technologies and practices drawn from the advent of Cloud Computing

