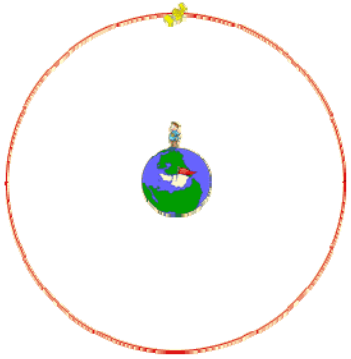
GSAW 2016

TRUE OPERATIONS AUTOMATION: FROM A GEO FLEET TO A SINGLE LEO SATELLITE

INNOVATING SOLUTIONS

CHALLENGE

- Satellite operations are simple and can be largely anticipated



- Large fleet, large team

- Humans needed (even if subsystems automated)

- Tedious tasks

VISION

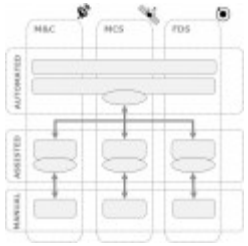
- End-to-end unattended automation

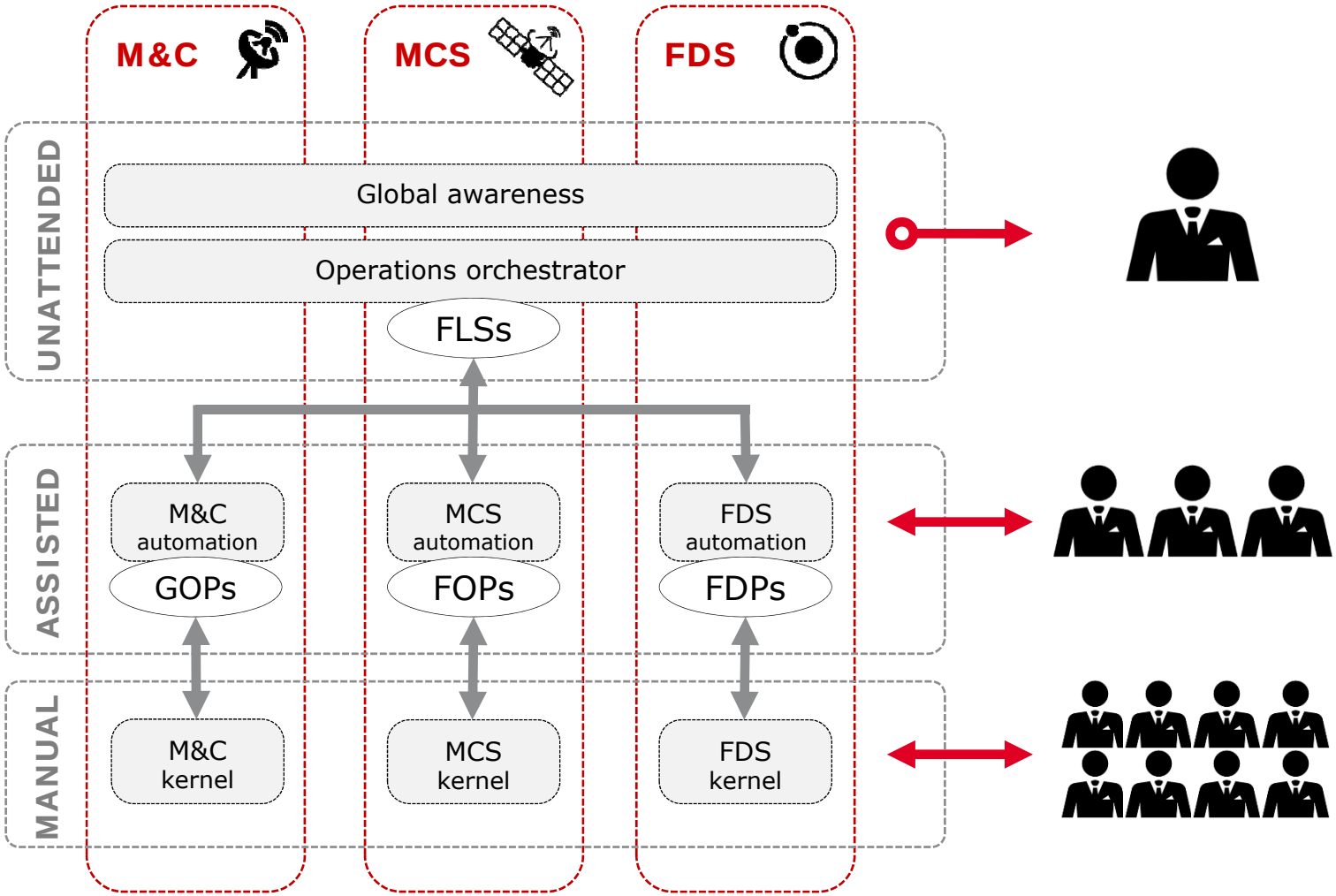
- Subsystems orchestrated

- One (1) supervisor

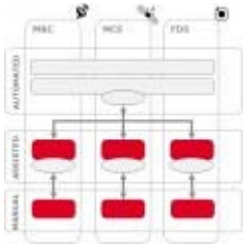
- Keep the manual mode!

SOLUTION

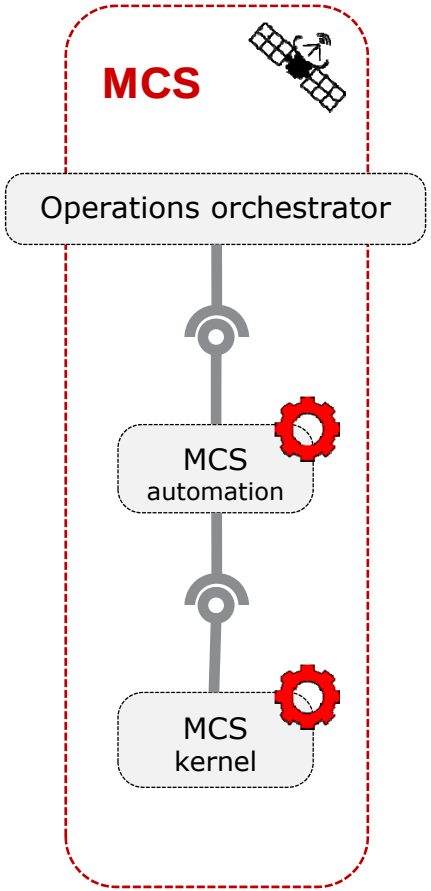




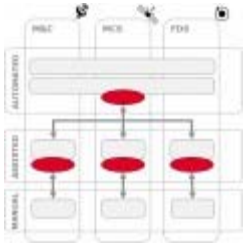
SUBSYSTEMS KERNELS AND AUTOMATION COMPONENTS



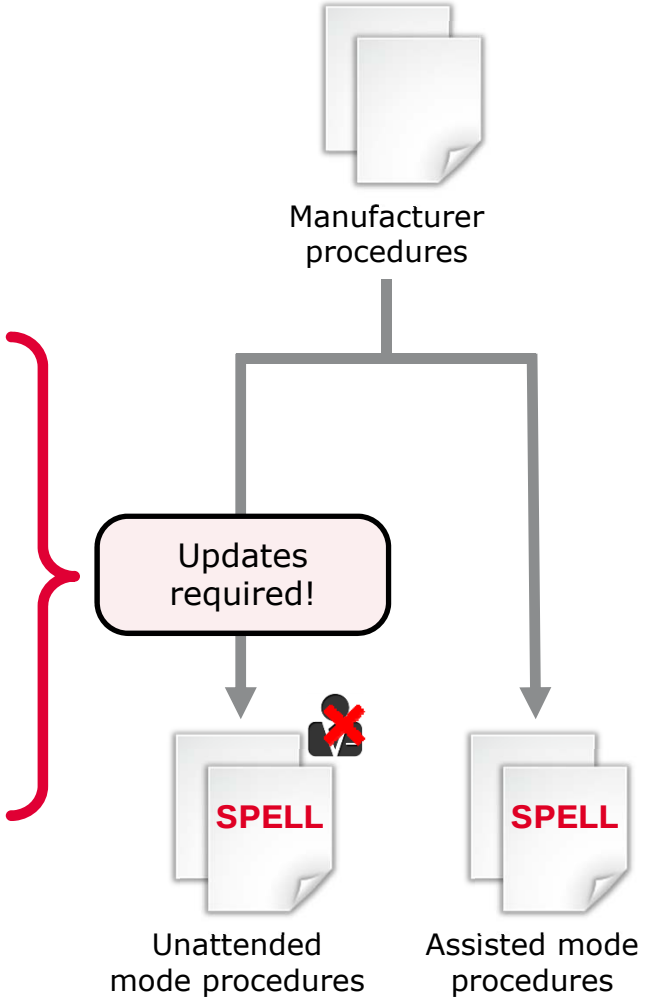
- The subsystems kernels shall
  - Be automatable
  - Expose an automation API
- The automation components shall
  - Exploit the kernel automation API
  - Be controllable
  - Expose a control API to be used by the orchestrator



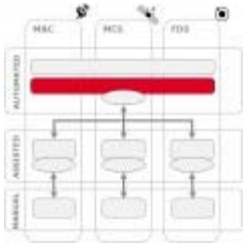
PROCEDURES



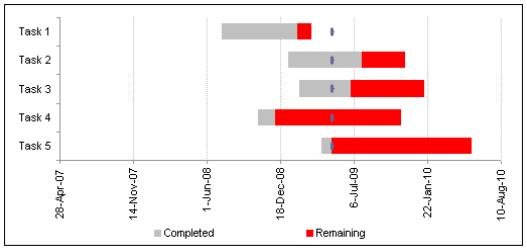
- Assisted mode
  - Rewrite or convert manufacturer FOPs to express them in the subsystem automation language
- Unattended mode
  - Remove user interaction
  - Pre- and post-checks
  - Support the switch from unattended to assisted mode
  - Provide feedback upon non-nominal paths being taken
  - Handle inputs/outputs via central data repository



OPERATIONS ORCHESTRATOR



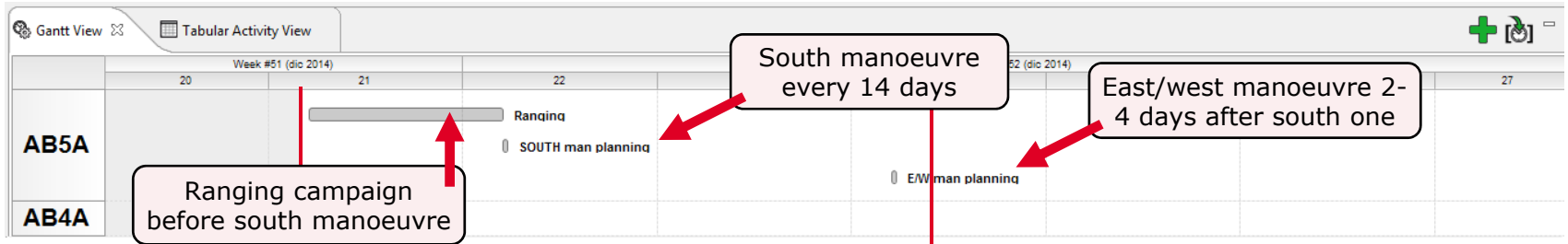
- The orchestrator may take a long-term plan from a MPS and allows short-term plan approval
- API for external systems to add unplanned activities (such as payload reconfiguration)
- Activities are shown in a Gantt display



- Resource conflicts are detected and reported
- Orchestration includes:
  - Chain of activities for different subsystems
  - Dependencies and data exchange
  - Scripted activities for dynamic planning

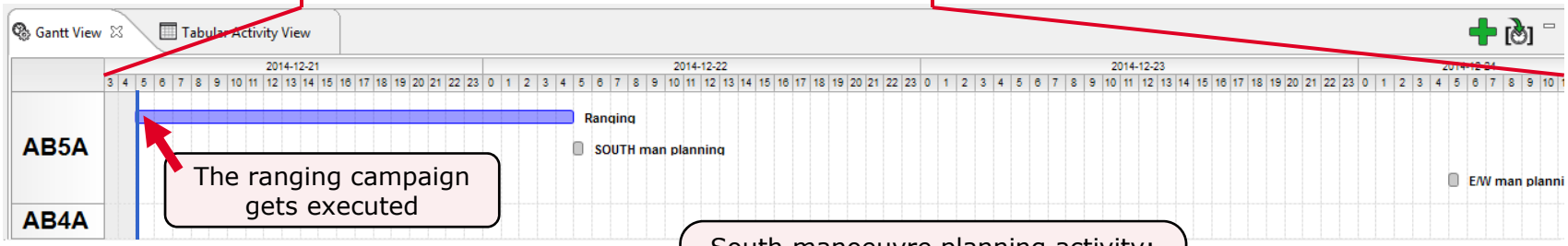
ORCHESTRATOR: DYNAMIC PLANNING

Planning

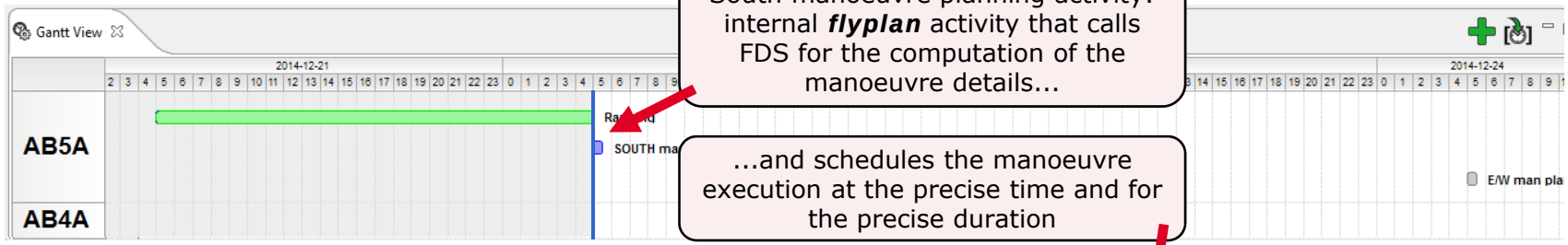


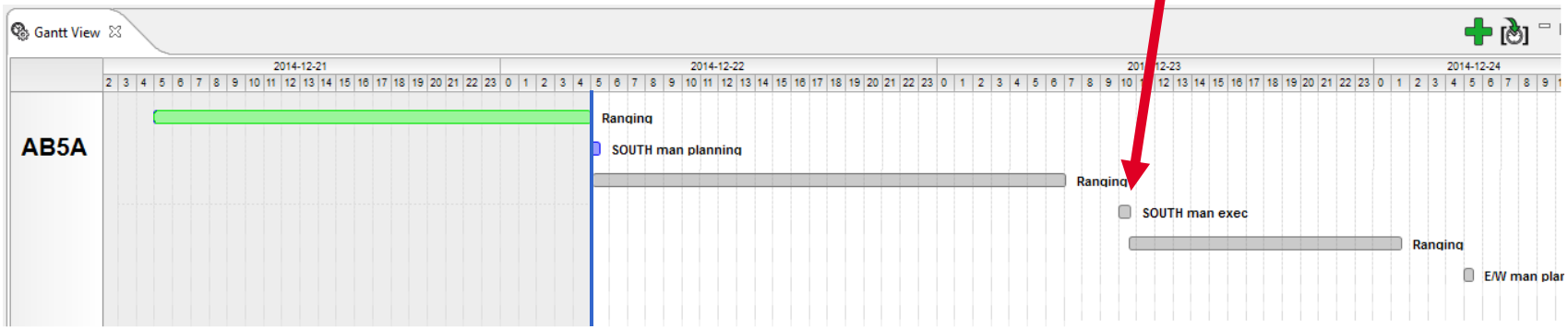
Execution

T_1

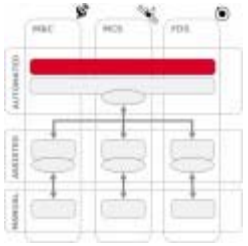


T_2





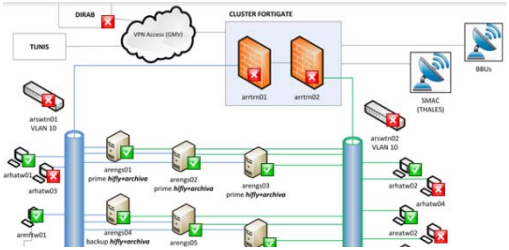
GLOBAL AWARENESS



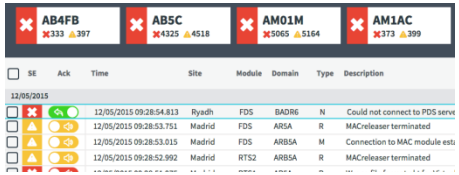
- Master Fleet Terminal (MFT)

Operations orchestrator (***flyplan***)

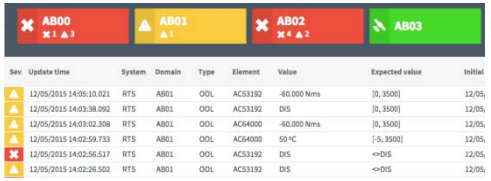
Infrastructure monitoring (NMS)



Centralized logging (*centralLog*)

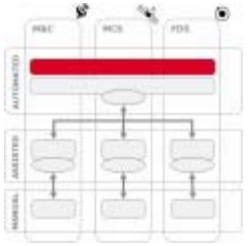


Alarms (*fleet dashboard*)

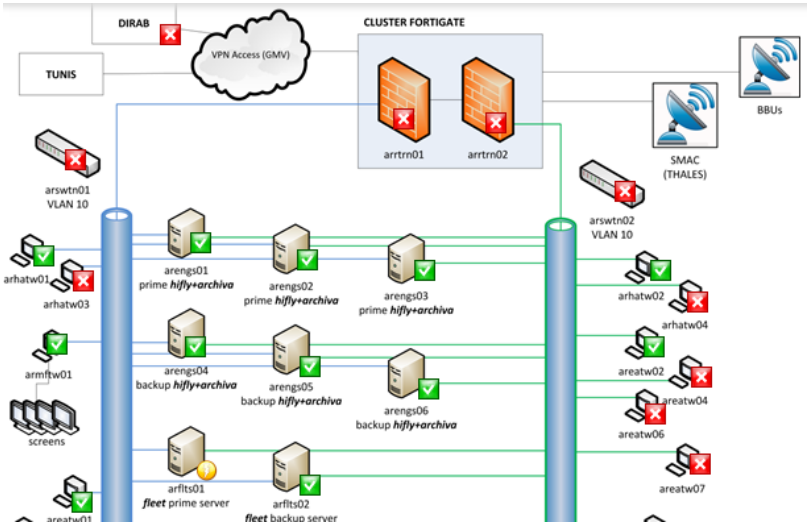


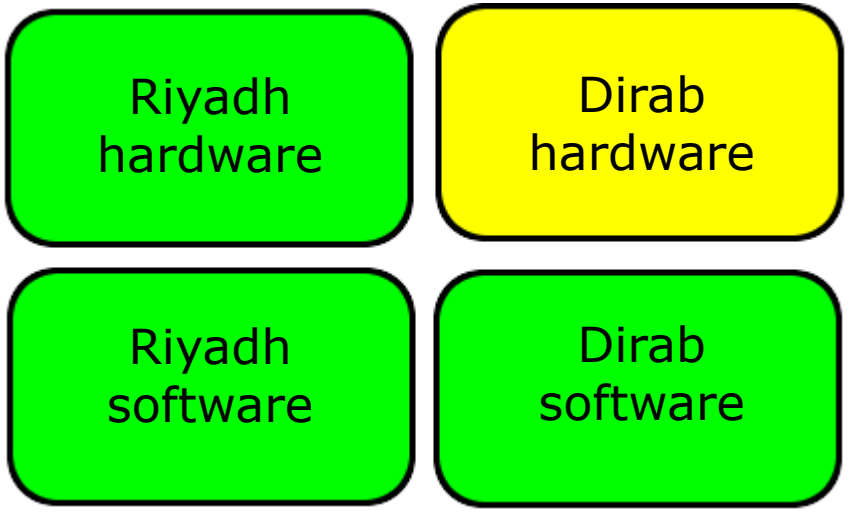
- Monitoring of plan execution
- Notify non-nominal situations
  - Drill-down to offending issue
  - Interact with the plan (stop/resume, shift...)
  - MCS workstations ready for intervention (assisted mode)

GLOBAL AWARENESS: INFRASTRUCTURE MONITORING

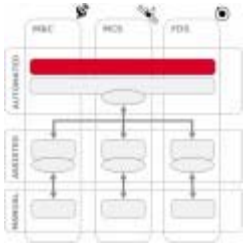


- NMS
  - Independent hardware and software monitoring
  - Alarm routing to the centralized logging module (next slide)
  - Multiple views (tactical, network, processes...)

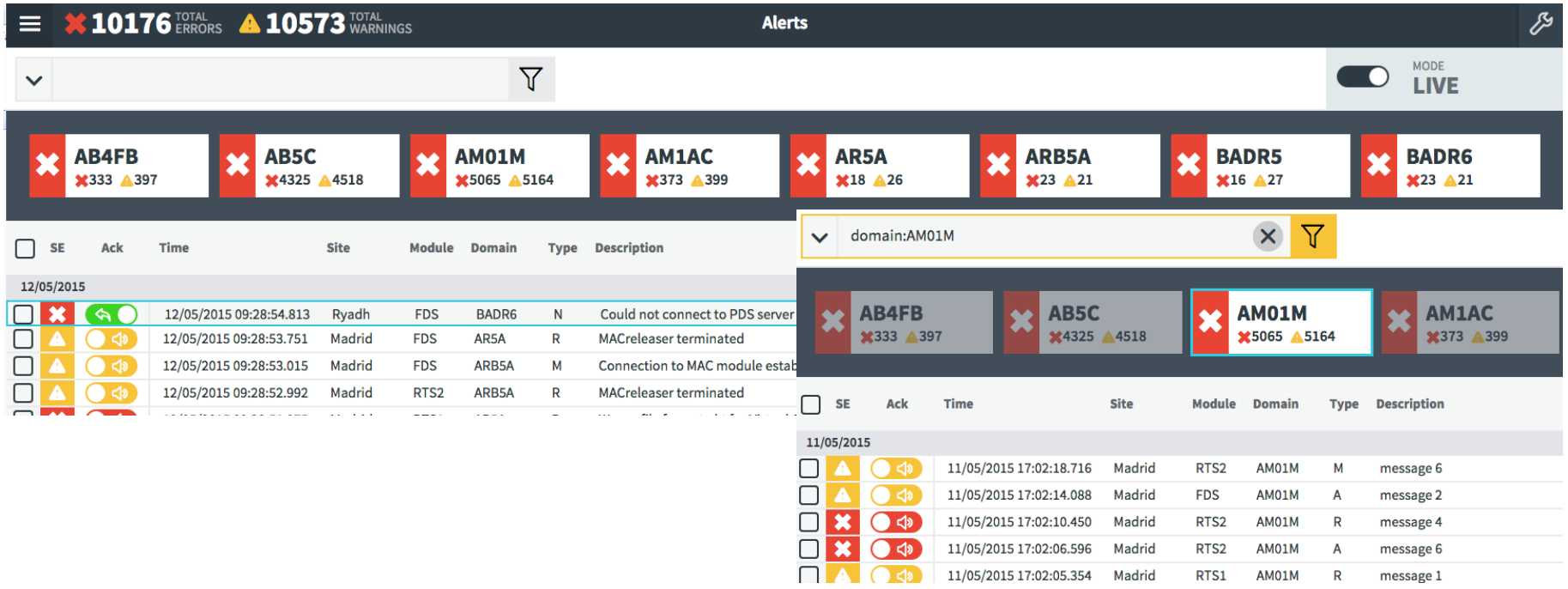




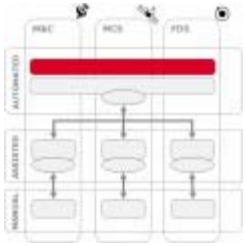
GLOBAL AWARENESS: CENTRALIZED LOGGING



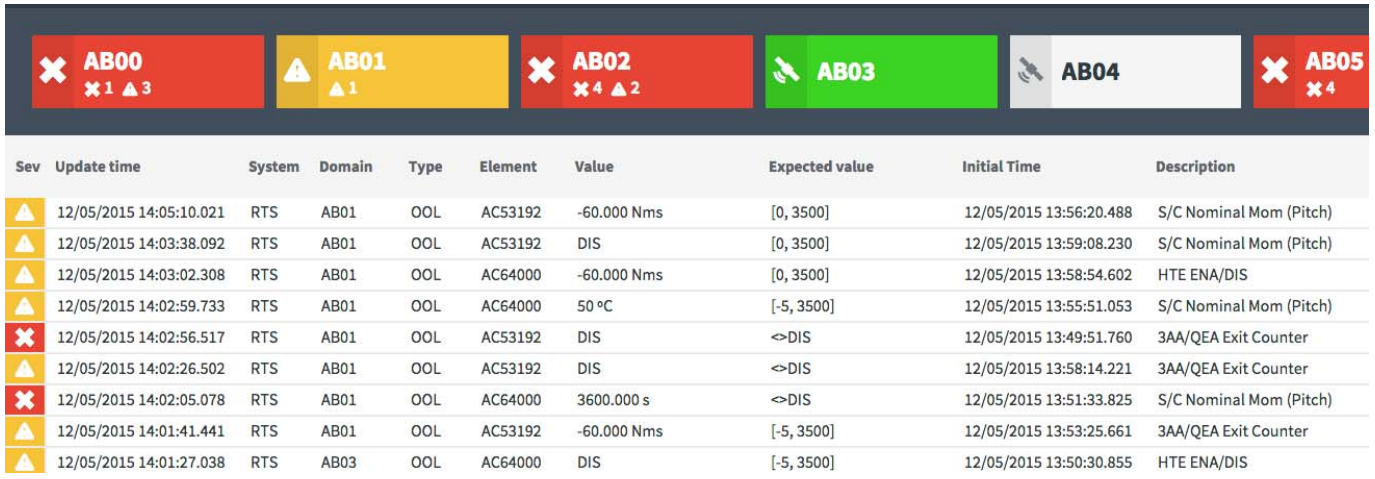
- *centralLog*
  - Selected messages from all subsystems
  - Only application with audible feedback
  - Error and warning messages acknowledge
  - Live and retrieval modes



GLOBAL AWARENESS: ALARMS (OUT OF LIMITS)



- *fleet dashboard*
  - Current list of satellite alarms (out of limits, status of TM link)
  - No sound
  - No acknowledge
  - Live mode only



Sev	Update time	System	Domain	Type	Element	Value	Expected value	Initial Time	Description
▲	12/05/2015 14:05:10.021	RTS	AB01	OOL	AC53192	-60.000 Nms	[0, 3500]	12/05/2015 13:56:20.488	S/C Nominal Mom (Pitch)
▲	12/05/2015 14:03:38.092	RTS	AB01	OOL	AC53192	DIS	[0, 3500]	12/05/2015 13:59:08.230	S/C Nominal Mom (Pitch)
▲	12/05/2015 14:03:02.308	RTS	AB01	OOL	AC64000	-60.000 Nms	[0, 3500]	12/05/2015 13:58:54.602	HTE ENA/DIS
▲	12/05/2015 14:02:59.733	RTS	AB01	OOL	AC64000	50 °C	[-5, 3500]	12/05/2015 13:55:51.053	S/C Nominal Mom (Pitch)
✖	12/05/2015 14:02:56.517	RTS	AB01	OOL	AC53192	DIS	<>DIS	12/05/2015 13:49:51.760	3AA/QEA Exit Counter
▲	12/05/2015 14:02:26.502	RTS	AB01	OOL	AC53192	DIS	<>DIS	12/05/2015 13:58:14.221	3AA/QEA Exit Counter
✖	12/05/2015 14:02:05.078	RTS	AB01	OOL	AC64000	3600.000 s	<>DIS	12/05/2015 13:51:33.825	S/C Nominal Mom (Pitch)
▲	12/05/2015 14:01:41.441	RTS	AB01	OOL	AC53192	-60.000 Nms	[-5, 3500]	12/05/2015 13:53:25.661	3AA/QEA Exit Counter
▲	12/05/2015 14:01:27.038	RTS	AB03	OOL	AC64000	DIS	[-5, 3500]	12/05/2015 13:50:30.855	HTE ENA/DIS

APPLICATION CASES

- Trade-offs performed by our customers have concluded that they will apply fully-automated operations

- GMV's full automation solution has been adopted in two scenarios:

  - (GEO) Fleets

  - Low cost mission: CHEOPS **CH**aracterising **E**x**OP**lanet **S**atellite
    - The CHEOPS mission is a partnership between Switzerland and ESA's Science Programme (first S-class mission from ESA)
    - Participation from a number of European countries Austria, Belgium, France, Germany, Hungary, Italy, Portugal, Spain, Sweden, and the United Kingdom
    - http://sci.esa.int/cheops/
    - http://cheops.unibe.ch/

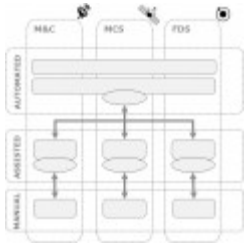
TELECOM FLEET OPERATIONS

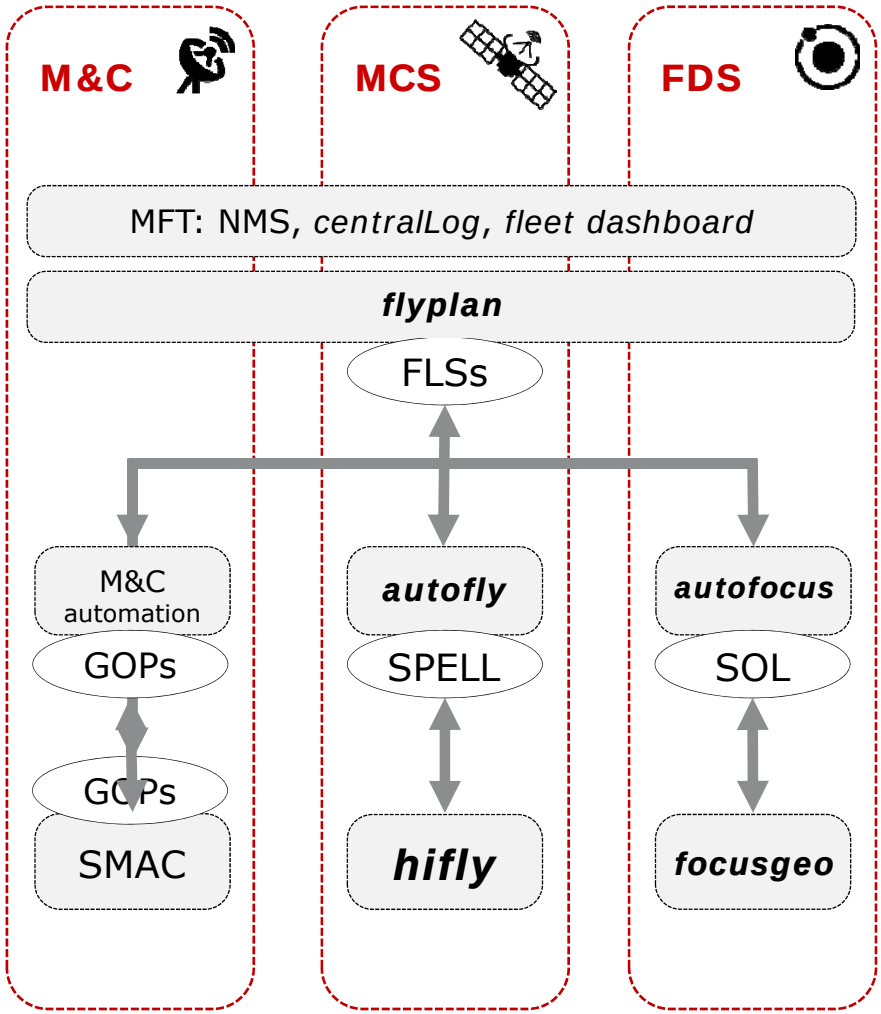
- 2-30 Geostationary satellites.
- +1 spacecraft every 1-4 years.
- Few routine operations per week.
- Operations involve FDS (comput.), M&C (ground) and MCS (sat).
- Spacecraft is always visible → MCS in the operations loop
- Controllers team cannot grow linearly → Need to automate

LOW COST MISSION OPERATIONS

- Relatively simple routine activities.
- Limited number of interfaces within ground systems and well defined and fixed processes (in routine)
- Operations involve FDS, G/S and MCS
- Unmanned downlink passes
- Manned uplink passes for monitoring the automation system
- Heavy budget constraints → need to automate operations + need of simple/reused systems

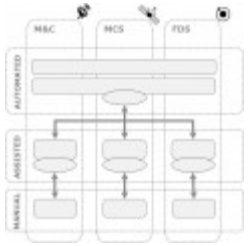
GEO FLEET CASE

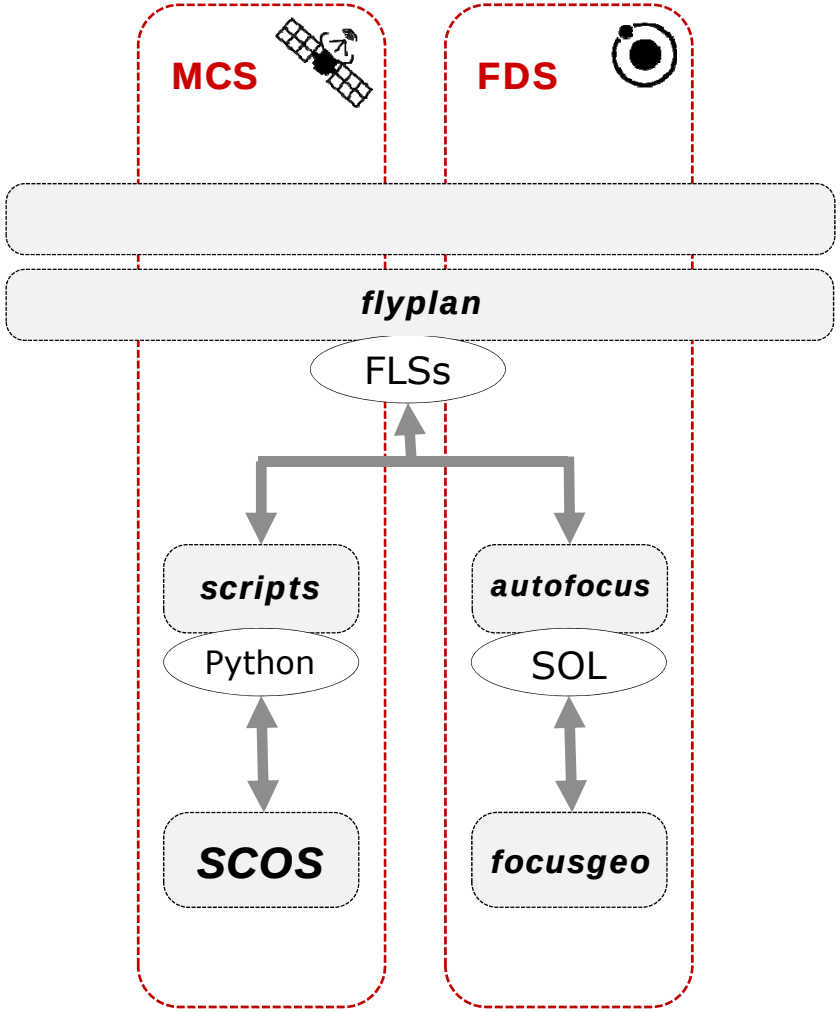




- MFT: Four wall-mounted 55" displays plus two monitors
- ***flyplan***, new fleet sequences
- Thales' SMAC, ***flyplan*** interface
- GMV's ***hifly*** and ***autofly***
- Airbus' PIL procedures → SPELL with SES' PIL2SPELL translator
- Unattended mode: a few services added to ***hifly*** & SPELL
- GMV's ***focusgeo*** and ***autofocus***
- New SOL procedures

LOW-COST MISSION





- ***flyplan***, new sequences
- MCS based on ESA's SCOS-2000
- MCS Automation: thin layer based on simple python scripts (basic requirements, no assisted mode)
- Relatively simple operations:
  -pass-independent, and
  -pre, during, post-pass activities
- GMV's ***focusgeo*** and ***autofocus***
- New SOL procedures

LESSONS LEARNT

- Manual → assisted automation is tough, → unattended tougher
- End user involvement is always important, here critical
- Unattended operations
  - No human will check your thruster firings: extensive data validation and integrity
  - When something goes wrong, tools and information shall be available
  - Put practices in place for keeping the operational knowledge
- Technical corner:
  - Python for automation - http://en.wikipedia.org/wiki/Python https://code.google.com/p/spell-sat/
  - REST interfaces for orchestration - http://en.wikipedia.org/wiki/Representational_state_transfer
  - Responsive design for awareness - http://en.wikipedia.org/wiki/Responsive_web_design

> "A robot may not harm humanity, or, by inaction, allow humanity to come to harm."
>
> — The Zeroth Law, Isaac Asimov

Thank you

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INNOVATING SOLUTIONS