



SUCCESS IS NEVER GUARANTEED

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Former Head of ESA-STC Office in  
Kourou

## Keynote speech

Short introduction to the Centre Spatial Guyannais

Success is the result of good planning, sound engineering, foresight and hard work

Description situations that occurred at the launch site during the periods I worked there

1996 June Ariane 501 : explosion

2018 January VA 241 : double error

2018 March VS 18 O3B Launch March 2018 : Communication issues nearly derail the launch

2018 Multiple campaigns in parallel causes logistics hurdles

2019 July VV15 : design issue

2020 February and onwards: COVID impacts

2020 September VV16 COVID and hurricane impacting operations

2020 November VV 17 production / testing issue

2021 second half 2021 - Webb campaign during COVID

2022 February invasion of Ukraine

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June 1996 Ariane 501. AR4 qualified system reused on AR5 BUT contained SW loop that was NOT used. Delta AR4-AR5=> error



*CSG Progress report for 1996 provided to the PB*

Booster stage ignition proceeded as planned about 7 seconds after cryogenic main stage ignition.

The liftoff and start of the flight proceeded without incident until H +36.7s when the inertial reference systems declared a failure, causing sharp swivelling of the booster/main engine nozzles and consequently break-up of the structures.

After the loss of launcher integrity, the onboard neutralisation system ordered its destruction.

*On a positive note*

Despite this failure, the Ariane 501 launch qualified all Ariane-5 ground infrastructures and new technical systems at the CSG developed under the CSG 2000 plan (no launch base “red” during operations) and validated the operational safety procedures.



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# January 2018 VA 241 : error during launcher preparation

During the Ariane 5 VA241 mission, carried out on January 25, 2018 from the Guiana Space Center in French Guiana (South America), telemetry from the launcher was lost 9 minutes and 26 seconds into the flight because of a deviation in the trajectory. Signals from the two satellites were acquired after the nominal mission duration, and the spacecraft were confirmed to be in good health, but in an orbit at an inclination of 20 degrees, rather than the targeted 3 degrees. The apogee and perigee attitudes, however, were very close to the targeted values (249 x 45,234 km.). The analysis of data received during the first minutes of the flight, and the reconstitution of the trajectory, confirmed that the launcher and the flight program operated perfectly. The two satellites are now in the process of reaching their final orbital positions, using their own propulsion systems.

Investigations by the Independent Enquiry Commission showed that the trajectory anomaly resulted from an incorrect value in specifications for the implementation of the launcher's two inertial reference systems. Given the special requirements of this mission, the azimuth required for the alignment of the inertial units was 70 degrees instead of 90 degrees, as is most often the case for missions to geostationary transfer orbit. This gap led to the 20-degree shift to the south in the launcher trajectory from the initial seconds of flight. The cause of the trajectory deviation, therefore, was due to a bad specification of one of the launcher mission parameters that was not detected during the standard quality checks carried out during the Ariane 5 launches' preparation chain.

The Independent Enquiry Commission's work has highlighted the need to increase the robustness of the control of certain data used in preparation of the mission. Its recommendations are intended to strengthen the process of developing and verifying the documents required for launcher preparation and to introduce additional consistency checks.

With the cause of the anomaly perfectly understood and corrective measures clearly identified, Arianespace and ArianeGroup immediately implemented the recommendations of the Independent Enquiry Commission. Applied to the current Ariane 5 launch campaign, they should enable the next flight of this heavy-lift launcher in March 2018, following a Soyuz mission.

VA241 lifted off as planned, was followed by CSG TM and radar stations then disappeared. Contact with down range TM stations was not established.

Satellites were separated on time and contact with operators ground stations established.

*Extracts from AE Pressrelease*

Statement at the CRAL:  
Launcher performed perfectly

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## March 2018: VS18 with O3B : Multiple problems puts the launch date at risk



- 1) consequences of VA241 => flight safety recom. takes more time => launch slips Tue 6.3 to Fri 9.3  
=> negotiations with staff if launch J+1, J+2, J+3
  - 2) Feb 21 and 22 Air France strike disrupts PAR-CAY
  - 3) March 2: Base readiness Review. Safety not ready  
March 3: base Readiness Review bis. Safety ready
  - 4) March 4 America II telecom cable is cut  
CSG is cut-off from outside world  
ESA Office has 4G connection.... until March 7
  - 5) March 7 & 8 Dress rehearsal (RG)  
March 8: no internet , no telephone
  - 6) Launcher Readiness Review (RAL)  
No telecommunications during RAL.  
Problems also in Martinique and Surinam  
**Clients need telecom links => launch at risk**  
Soyuz can launch J+1, J+2 etc => poss on Sunday  
How long can Soyuz remain on the pad? 100 hours  
but .....
- Plus batteries only OK until March 11

**Launch 180309 H0 13:37:06**

H0 – 5 hrs weather conditions not great

H0 – 10 min unfavourable winds => countdown stops  
=> 2<sup>nd</sup> tentative at +33 min ie 14:10:06

**Soyuz launches on the dot**

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# March 2018: VS18 with O3B

VS 18 O3B Launch March 2018 : Multiple issues : Communication Pb (Telecom Provider to Fr Guiana) + Soyuz on the pad

Extract from my reporting to D-STC

## 180305 Monday

The reason for the delay is the implementation of the recommendations following the various VA 241 investigation. As far as I know these are procedural changes.

The Soyuz can be launched J0, J+1, J+2 => if, for some reason (weather, technical glitch...) we can not launch Friday the next attempt is Saturday or even Sunday.

This necessitates negotiations with the labour unions and possibly special measures .

Meetings are being held to ensure the CSG capacity to do so.

My notes: not all actions resulting from the recommendations coming from the VA241 investigations have been concluded

## 180308 RAL . My notes

Q: Soyuz has a 10 day limitation for staying on the pad. Om vädret är emot oss do we have to go back to MIK. Reply: then we discuss w our Russian partners, no need to worry. Peres2, I suggest you start preparing the waiver just in case. How many days can we delay (launcher not fuelled)? RU : on the 1st Soyuz we spent 18 days on the pad, and we had a 100 hour waiver. But all necessary analysis had been done. Peres: frågar om el systems are covered. New limit of KSE batteries is March 11. RU: we can chg the batteries on the launch pad. We have done it before. The ones we removed are being recharged (CB can be used again?). Expiration date of KSE batteries are now March 19.

RU gråhårig Kapitonov el dyl (CTLs). I see a big pb in delaying the launch so please keep the date.

Peres2 : if we have to do the waiver we will provide you (client) with the justification file.

Conclusion 3-stage + Fregat are ready.

## 180309 J0

Event of the week: Communication seriously affected by Americas II cable rupture

Apart from the countdown the event of the week was the serious disturbance of communications between French Guyana and the rest of the world. The Atlantic cable was cut Sunday. Initially communications were routed via a backup route Fr Guiana -> Surinam . \_ Martinique which allowed intermittent internet for some clients of Orange.

Arianespace clients were not happy and CNES CSG (Digicel) were more or less cut off. ESA (Orange) functioned well until March 7 afternoon. At this point we were all cut off.

The RAL started with no communication available and the launch at risk.

Apparently two more problems with the communication had occurred, first in Martinique and then in Suriname.

The client made a special observation about this "weakness" in his closing remark at the RAL.

VS18

The necessary modifications on Flight Safety were finished the day of RPB2 bis.

March 9 is a Friday. Soyuz can be launched J0/J+1/J+2 so UEBS was requested to take all necessary precautions to allow to launch Friday, Saturday or Sunday. A meeting was held with UEBS Monday evening and this was confirmed.

RPB bis held March 6

RG Tri-étage RAL March and Point météo held March 8

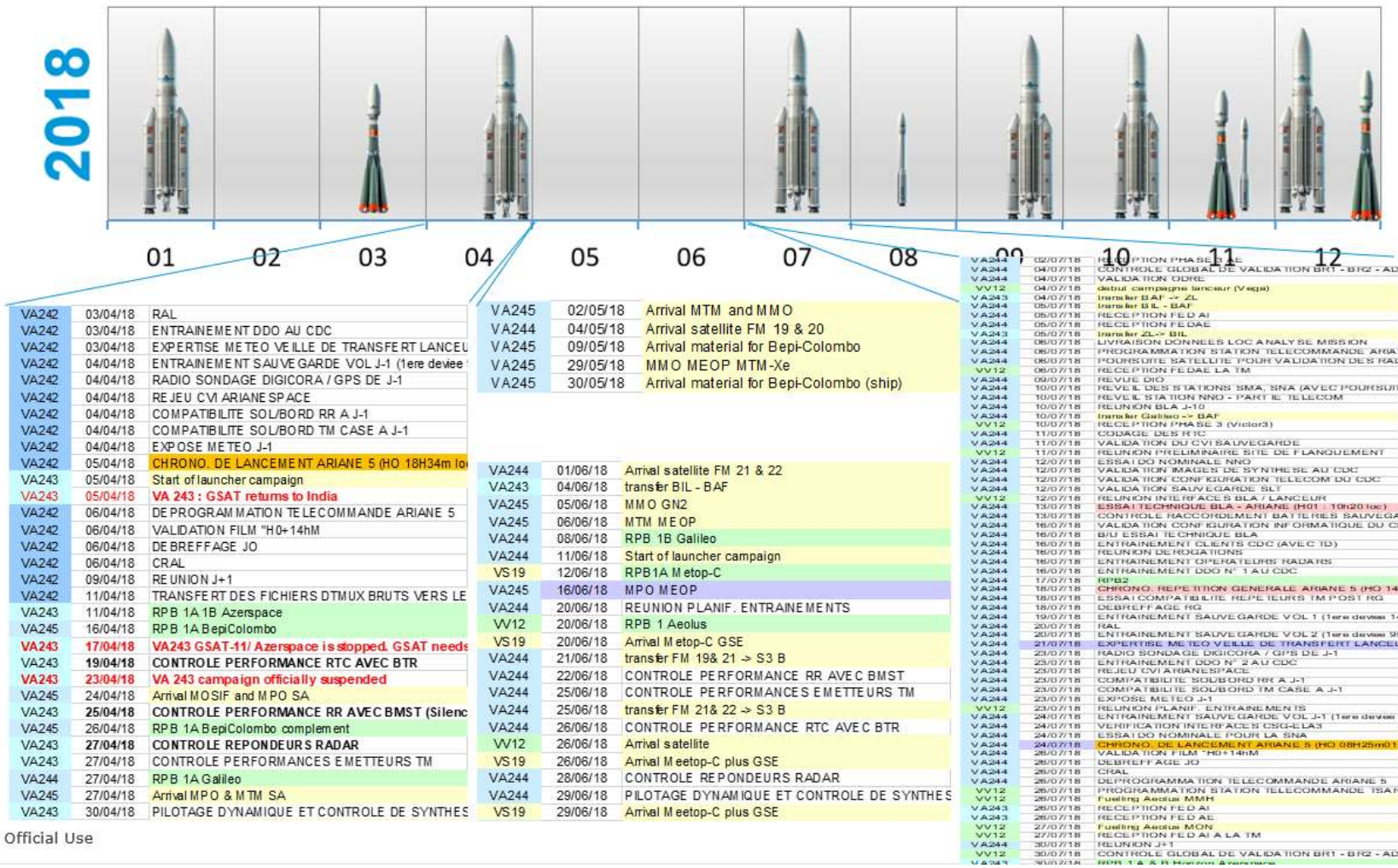
At the RAL Russian experts clearly indicated they want VS18 to depart. When pressed they mentioned earlier derogations that were agreed on number of days the launcher can remain on the pad and number of hours it can remain fuelled (not here in Kourou though).

They added that each case has to be analysed separately.

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# April 2018 VA 243 and VA 245 : multiple campaigns and unexpected problems



Launch base activities.  
March – Aug 2018

Planning dates	180316
VA243 GSAT-11 / Azer space-2	180518
VA244 Galileo	180725
VV12 Aeolus	180821
VS19 METOP	180918
VA245 Bepi Colombo	181010

\*\*\*\*\* **GSAT problem** \*\*\*\*\*

ISRO has a pb with a GSAT satellite => decides #11 -> India for RF check =>

- \* GSAT-11 transport pb
- \* VA243 BIL->BAF and VA244 to BIL
- \* Azerspace to fly with Horizon
- \* not enough cleanrooms or offices

## actual dates

VA244 Galileo	180725
VV12 Aeolus	180822
VA243A Horizons / Azer space-2	180925
VA245 Bepi Colombo	181019
VS19 METOP	181120

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- For Official Use



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# July 2019 VV15 : design issue

## Extract from AE Pressrelease

These investigations confirm that all preparation and countdown operations for the VV15 launch, as well as the flight conditions until after the ignition of the Zefiro 23 second stage (Z23) proceeded normally. In particular:

- The operation of the P80 first stage (engine Ignition, atmospheric phase, P80 propulsion and separation) was nominal; all parameters were as expected and in line with those from preceding flights.
- The ignition and powered phase of the Z23 stage was nominal during the first 14s 25ms and all parameters were as expected and in line with those for preceding flights.

The anomaly occurred at 130s 850ms, based on the following observations:

- At 130s 850ms, a sudden and violent event occurred on the Z23 motor.

This event led to a breakup of the launcher in two main parts: the Z23; and the assembly composed of the fairing, satellite, flight adapter, AVUM and the Zefiro 9 stage (Z9).

The Commission has proposed:

- An exhaustive verification plan of its findings based on analyses and tests,
- A set of corrective actions on all subsystems, processes and equipment concerned.

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# February 2020: issues beyond CSG control : COVID

## Launch planning

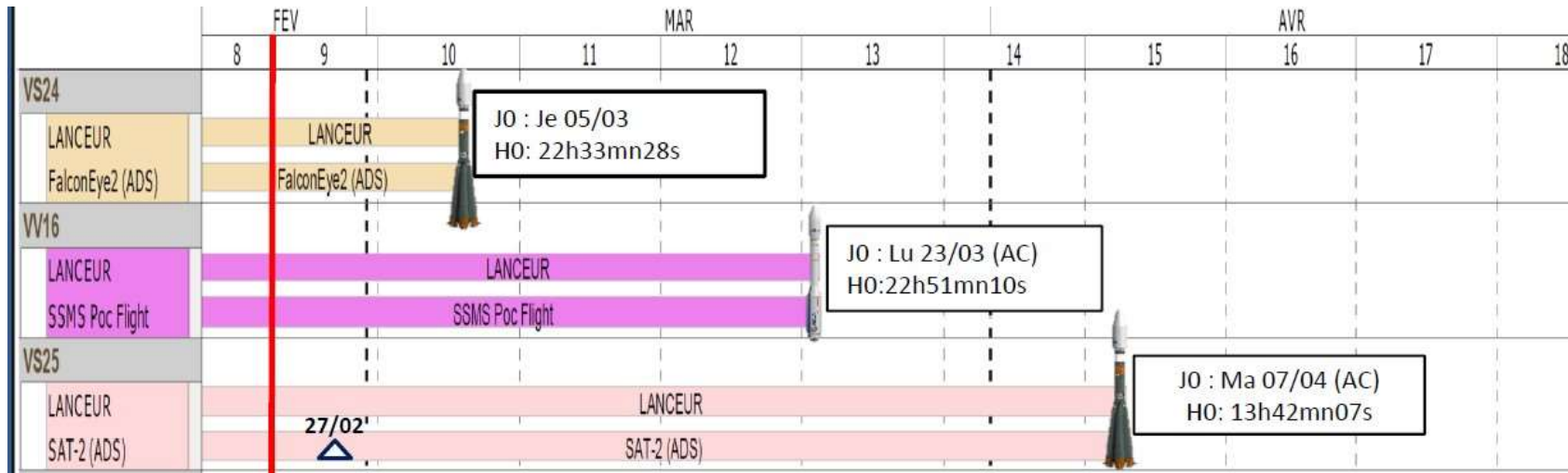
VA252	JCSAT 17 and GEO KOMPSAT 2B	2020-02-18
VS24	Falcon Eye-2	2020-03-05
VV16	RTF SSMS multiple satellites	2020-03-23
VS25	CSO	2020-04-early
P120	QM2 static firing test	2020-04-27
VA253	GSAT-20 Bsat 4b	2020-05-mid
VV17	Seosat and Taramis	2020-06 early
VA254	Galaxy 30-MEV-2 and Quantum	2020-07-mid
VA256	James Webb telescope	2021 Aug – Oct

multiple difficulties due to COVID

## Situation at CSG Feb 21, 2020

Multiple satellites on site  
 Multiple launchers on site  
 Preparations for 2<sup>nd</sup> static firing of P120 booster AR6 config

France is confined March 17  
 activities stop



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## February 2020: issues beyond CSG control : COVID: Instructions from La Prefecture

Impact on daily life and work

French Guiana is confined March 17 – May 11, just like the rest of France => CSG is closed. Safety critical operations continue

May 12 CSG reopens and work resumes under COVID restrictions, not all staff return.

In July French Guiana is reconfined.

Aug 22 some zones are de-confined.... part of the time. Curfew remains in place all days 23h-05h

Restaurants remain closed.

In Oct 2021 the Tribunal de Cayenne declares that restaurants , bars and discos can stay open until 22h30 with the pass sanitaire.

At this point life outside CSG eases. Inside CSG COVID restrictions apply

Restrictions impact: presence in meeting rooms, in offices, masks are to be worn if > 1 person in an office, room etc etc

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# February 2020: issues beyond CSG control : COVID: Instructions from La Prefecture

- 200807\_attestation-deplacement-outr-mer.pdf
- 200807\_attestation-deplacement-outr-mer-anglais.docx
- 200821\_health\_declaration\_p\_2-attestation-frontieres-exterieures-en.docx
- 201231\_31-12-2020-justificatif-de-deplacement-professionnel-couvre-feu-pdf.pdf
- 210122\_deplacement\_aerien\_attestation.pdf
- 210122\_derogation\_CB.pdf
- 210125\_engagement-sur-l-honneur-plus-de-11-ans-espace-europeen.pdf
- 210126\_outr-mer-engagement-sur-l-honneur-plus-de-11-ans.pdf
- 210205\_COVID-19\_Attestation deplacement Guyane-autre point territoire national (2).pdf
- 210205\_COVID-19\_Attestation deplacement international à destination de la Guyane.pdf
- 210205\_COVID-19\_Attestation deplacement international au départ de la Guyane.pdf
- 210312\_Regles\_Summary.JPG
- 210316\_conditions voyage guyane.docx
- 210330\_conditons voyage.docx
- 210330\_travel conditions\_EN.docx
- 210402\_COVID-19\_Attestation Couvre-feu.pdf
- 210402\_règles en vigueur Prefecture.docx
- 210409\_TRAVEL CERTIFICATE TO METROPOLITAN FRANCE.docx
- 210409\_travel conditions.docx
- 210409\_travel declaration ENG..pdf
- 210422\_Conditions vols 2021.pdf
- 210426\_attestation-de-deplacement-vers-la-france-metropolitaine-depuis-la-guyane.pdf
- 210501\_couvre\_feu.JPG
- 210512\_confinement\_FrGuy.JPG
- 210513\_COVID\_restrictions.JPG
- 210513\_COVID\_restrictions-2.JPG
- 210526 - Attestation deplacement professionnel-2\_CB.docx
- 210603\_Couvre\_feu.PNG

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- 211027\_P0973-20211027-arrêté global covid-V74.pdf
- 211105\_P0973-20211105-arrêté global covid-19.pdf
- 211108\_COVIDINFO.pdf
- 211110-Prorogation arrêté lutte contre COVID.pdf
- 211118\_P0973-20211118-arrêté global covid-V77-num.pdf
- 211120\_Fr\_Guy\_Zone\_rules.PNG
- 211129\_travel\_rules.PNG
- 211129\_zones\_vert.PNG
- 211210\_P0973-20211210-arrêté global covid-V79.pdf
- 211215\_travel\_rules.PNG
- 211218\_P0973-20211218-arrêté global covid-V80.pdf
- 211229\_travel\_rules.PNG
- 220107\_Fr\_Guy\_Zone\_rules.PNG
- 220114\_Fr\_Guy\_zone\_rules.PNG
- 220202\_Conditions-deplacements-aeriens.png
- 220202\_travel\_rules.PNG
- 220203-arrêté global covid-V85.pdf
- 220204\_Zone\_rules.png
- 220211-arrêté global covid-V86.pdf
- 220212\_zone\_rules.PNG
- 220218\_travel\_rules.PNG
- 220218\_travel\_rules\_Antilles.PNG
- 220221-arrêté global covid-V88.pdf
- 220222\_zone\_rules.PNG
- Acte d'engagement - Respect des règles de l'auto-isolement travaillé.pdf
- Conditions voyages auto-isolement UEBS-21-004 Ed9 23.06.21.pdf
- Les Engagements de l'auto-isolement travaillé Version 2.pdf

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# February 2020: issues beyond CSG control : COVID

## Launch planning

		early Feb 2020
VA252	JCSAT 17 and GEO KOMPSAT 2B	2020-02-18
VS24	Falcon Eye-2	2020-03-05
VV16	RTF SSMS multiple satellites	2020-03-23
VS25	CSO	2020-04-early
P120	QM2 static firing test	2020-04-27
VA253	GSAT-20 Bsat 4b	2020-05-mid
VV17	Seosat and Taramis	2020-06 early
VA254	Galaxy 30-MEV-2 and Quantum	2020-07-mid
VA256	James Webb telescope	2021 Aug – Oct
<i>VV 16 J-1 Aug 29 RG</i>		<i>QM2 Oct 7, 2020</i>

## actual dates

	actual dates	delta
	2020-02-18	ok
	2020-12-01	9 months
	2020-09-02	6 months
	2020-12-29	9 months
	2020-10-07	5 months
	2020-08-15	3 months
	2020-11-16	5 months
	2021-07-30	“normal”
	2021-12-25	

*VS25 RG Dec 24, 2020*



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# All the time: issues affecting our Telemetry Stations : Launch Eastwards

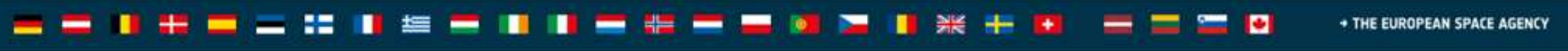
TM Collection from down range stations  
TM Distribution to users  
DO Distribution to downrange stations

- H1 : EAPs burn out (then separation)
- K1 : Fairing jettison
- H2 : Vulcain2 cut-off (then EPC separation)
- H3 : HM7B cut-off
- H4.1 : JCSAT-17 separation
- H4.2 : SYLDA separation
- H4.3 : GEO-KOMPSAT-2B separation
- PASV LOX/LH2 : ESC-D passivation



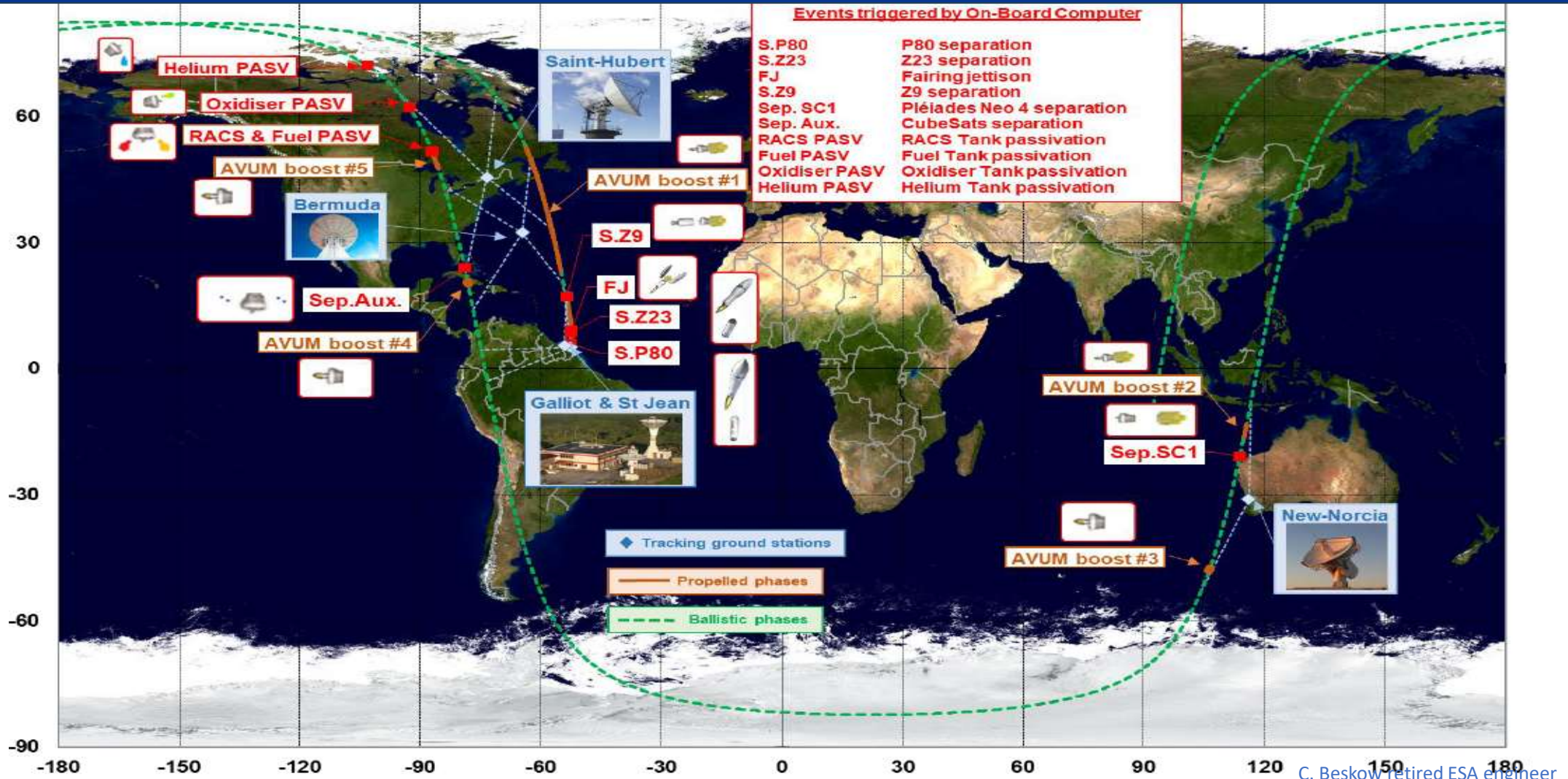
L/V Ground tracking stations

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# All the time: issues affecting our Telemetry Stations : Launch North



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# TM stations used by CSG

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## Several different types of agreements

On trouvera dans ce catalogue 3 types de stations :

- Les stations dites permanentes : ce sont des stations entièrement équipées (aérien + kit TM) qui présentent la particularité de pouvoir être mises en oeuvre dans un délai très court (inférieur à 2 mois),
- Les stations existantes : ce sont des stations mises en oeuvre par des partenaires du monde spatial qui ont une activité opérationnelle et qui nous offre la capacité d'utiliser une partie de leur infrastructure (en général la partie Aérien). Leur mise en oeuvre demande une coordination opérationnelle et l'envoi d'un kit TM du CSG. Le délai de mise en oeuvre sera de l'ordre de 4 mois.
- Les sites d'accueil : ce sont des sites aménagés par le CNES qui permettent d'accueillir les différentes composantes d'une station (aérien + kit TM). Leur mise en oeuvre demande une anticipation pour réactiver le site. Leur mise en oeuvre sera de l'ordre de 6 mois.

### North

St Jean : Convention entre le RSMA et le CNES . Radar: Contract btw INTA and CNES  
 Agreement with the commune St Laurent to pose a mast for calibration purposes  
 Bermuda : Agreement negotiated with SSCC  
 Canada: Gatineau: Canada: un accord cadre tripartite (CSA/CCMEO/CNES)

### East

ASC: agreement ESA – UK covers the three launchers. Landing strip unusable  
 LBV: agreement ESA and **Gabon** => CNES is responsible => becomes ESA for that purpose  
 Malindi: Accord Tripartite KENYA – ITALIE – ESA. Pbs w customs  
 NNO : Accord Cadre n°17011 entre l'ESOC et le CNES  
 Azores: Agreement btw ESA and PT  
 SNA Boat: negotiated case by case, antenna installed each time  
 NZ, Awarua : used for ATV, basically they rented a field from a farmer and posed an antenna

### Ad hoc stations

Ex Jeju South Korea for VV16

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## February 2020: issues beyond CSG control : VV16 RTF Launch Campaign

VV16 was an important mission for two reasons

- 1) Return to Flight after failed VV15
- 2) proof of concept for SSMS Small Spacecraft MissionService

41 payloads from 400 kg to > 1 kg were to be delivered the same 550 km altitude 'Sun synchronous orbit', remaining lined up with the Sun for optimal Earth observing conditions

VV16 campaign was almost finished when the COVID restrictions were imposed

TBW or deleted

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# VV16 : 200902 Return to Flight + COVID and then comes Hurricane Maysak

VV16; COVID and Hurricane:

Launch date

200323-> 0601-> 0608-> 0617->0618-> 20? 23? 27 (1)-> 29(2)-> 2nd half Aug-> Sept 1->2

we use Jeju in South Korea with local staff (impossible to travel due to COVID)

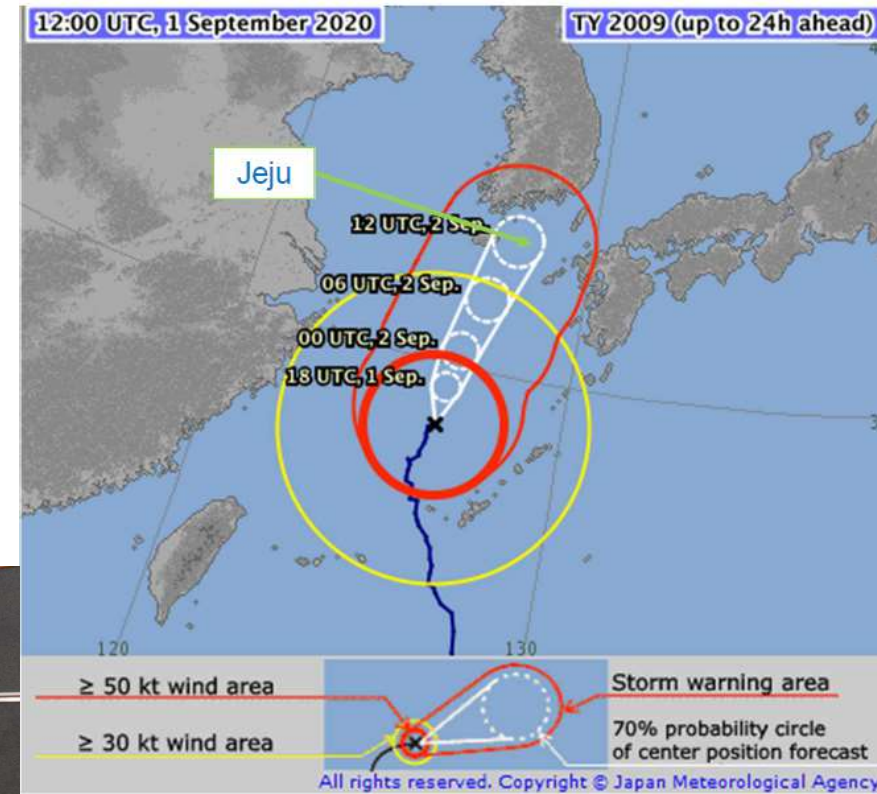
Jeju is non impassable => limits are

Vent moyen : 13.5 m/s (= 26,2kt = 46.8 km/h)

Rafale = 22,3 m/s (= 43,3kt = 79.2 km/h)

Meteo briefing data J-1 Situation Typhon Maysak

Pacifique Nord-Ouest



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## November 2020 VV17 : integration issue

### *Extracts from AE press release*

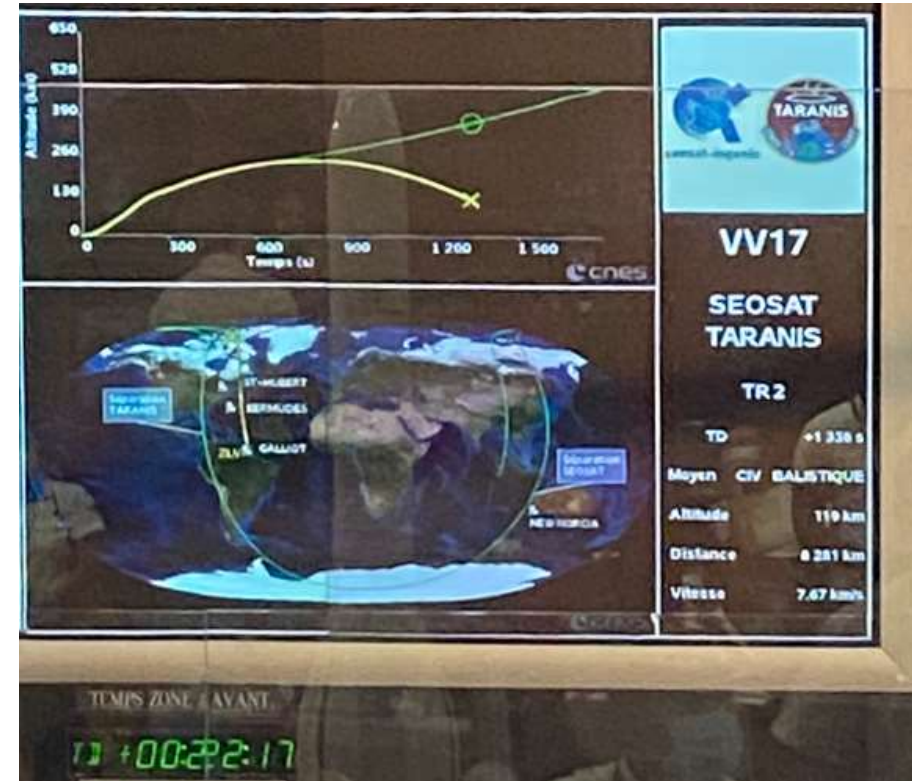
Initial investigations, conducted right after the launch with the available data, identified a problem related to the integration of the fourth-stage AVUM Thrust Vector Control (TVC) system as being the most likely cause of the loss of control of the launcher.

### *Extracts from AE press release*

...IEC concludes that the VV17 cause of failure is not attributable to a flaw in the qualification of the design but to the wrong routing and connection of the control lanes of the electro-mechanical actuators of the AVUM upper stage Thrust Vector Control (TVC) system, inverting steering commands and causing trajectory degradation leading to the loss of the vehicle.

The detailed series of causes are described as

- (i) a misleading integration procedure causing
- (ii) an inversion of electrical connections, not detected through
- (iii) the different control steps and tests executed between the integration of the AVUM upper stage and the final acceptance of the launcher due to some inconsistencies between specific requirements and prescribed controls.



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## July 2021: TM station issue during VA254 affecting VA 255 and 256 Webb Telescope

VA 254 July 2021. During launch preparations we are informed that the TM antenna on Ascencion Island has a mechanical problem. The bad news is that it can not change its elevation and it can not be repaired. The good news is that it can move, somewhat, in azimuth. VA254 will pass ASC low on the horizon => will be OK

MUST be fixed for VA255



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# Multiple Launch Campaigns: SW issues at the interfaces between the various systems

Numerous computer systems are implemented across the CSG



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# December 2021: Webb Telescope



Launch Date : 2108-> 211016 -> 211201 ->211218-> 211222-24 -> 211222->NET24...

Webb launched Dec 25th

NASA – ESA- CSA Cooperation

ESA contribution 1 instrument, the optical bench for a second instrument and the launch

=> it was an ESA Launch campaign but run by NASA

NASA Cleanliness instructions => took an hour to get suited up

=> people did not want to leave the cleanroom unnecessarily => far too many people inside

Multiple issues

- \* Security clearances
- \* Access to Webb
- \* High number of VIP visitors
- \* Very specific cleanliness requirements
- \* Specific requirements on the fairing
- \* one or two Ariane 5 launches in identical conditions before Webb launch

Etc

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# Modernisation of the CSG: introduction of a new radar

TBW

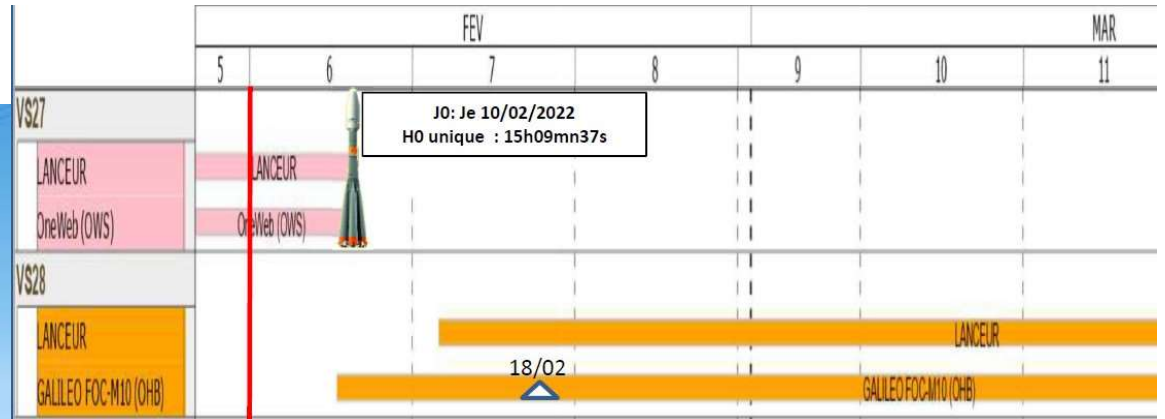
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# Issues beyond CSG Control: RU invasion of Ukraine Feb 24, 2022

CSG planning Feb 4, 2022



VA257  
MEASAT and GSAT  
planned JO: mid May 2022

VS27  
Rollout Soyuz Feb 7, 2022  
Launch Feb 10, 2022  
with One Web

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# Issues beyond CSG Control: RU invasion of Ukraine Feb 24, 2022: Impact on VA257

## Getting to French Guiana



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# Issues beyond CSG Control: RU invasion of Ukraine Feb 24, 2022: Impact on VA257

Initial planning launch Mid May 2022

Actual arrival GSAT 220519

Actual launch date 220622



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## Dec 2022: VV22 Vega –C first commercial flight

### *Extract from document presented at PB-STC March 2023*

Immediately following this launch failure, Arianespace CEO and ESA STS Director have set up an Independent Enquiry Commission (IEC), co-chaired by the Arianespace Chief Technical Officer and the ESA Inspector General, with the main objectives to identify the circumstances and the root cause of the failure, to propose measures, related to processes, design, quality and organization as needed to allow a safe and reliable return to flight of Vega-C on a permanent basis and to evaluate the need to implement such recommendation also, when relevant, to Vega missions.

The IEC activities were concluded in February 2022. The IEC report includes 22 recommendations.

#### *One-off activity*

*the full consolidation of the qualification file and in particular of the reproducibility of the as-built products in answer to IEC recommendations. In this frame, a check-up of the robustness of the industrial acceptance processes in coherence with the outcomes of the qualification program will be performed. Generic improvements will be implemented consequently not only on the design definition but also in terms of reliability and repeatability of processes, configuration management, non-conformances treatment, management rules.*

*As far as VEGA-C is concerned, a robust recovery plan aimed at demonstrating the reproducibility and stability of the qualified manufacturing and integration processes, will be performed on the whole launcher system industrial supply chain. Any process modification shall be assessed and tracked according to:*

- Criticality of the process, using a defined classification of the processes*
- Identification of the key characteristics of the process*
- Key acceptance criteria*
- Assessment and tracking of any modification introduced in the process, including key characteristics*

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## Dec 2022: VV22 Vega –C first commercial flight

xxx ***Extract from document presented at PB-STC March 2023***

### *Continuous activities*

*With the objective to reach a sustainable exploitation and focusing on the critical processes assessed as per para. 3.1.2, a reinforced accompaniment action plan will be implemented until FMC-05 as follows:*

- Limit tests of sample equipment and relevant expertise aiming at verifying the qualification margins on a production element,*
- Qualification audits aiming at verifying the compliance with the Qualification Requirements (incl. management, configuration control e.g.) in the whole supply chain. In case of non-conformances identified, the qualification status may be limited and specific qualification recovery actions may be requested.*
- In-flight prediction models development and calibration,*
- Delta qualification activities aiming at controlling the implementation of design changes on the operational Launch System (incl. Launch Range interface adaptations)*
- Specific reinforced follow up and monitoring activities on key production and operation activities will be implemented up to the end of the transition phase of Vega C*

C. Beskow retired ESA engineer



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## Concluding remarks : Success is never guaranteed: it is the product of hard work and luck

Key factors that increase the chances of succeeding

- \* Keep your element / component as simple as possible
- \* Test as you fly and fly as you test
- \* Maintain a healthy scepticism of good ideas and unnecessary improvements
- \* Robust change control
- \* Maintain the test and validation environment throughout the project lifetime  
events / failures / incidents that you never thought possible will occur
- \* Brainstorm and document all failures that could possibly occur, no matter how unlikely
  - what kind of data would you need in order to identify a particular error ?
  - what kind of actions would you need to take

etc

And... on a personal note: keep in mind that your creation might blow up or otherwise fail. Plan for it

C. Beskow retired ESA engineer



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