



ARIANE 5

THE STORY OF ONE OF THE MOST EXPENSIVE BUGS IN COMPUTER HISTORY

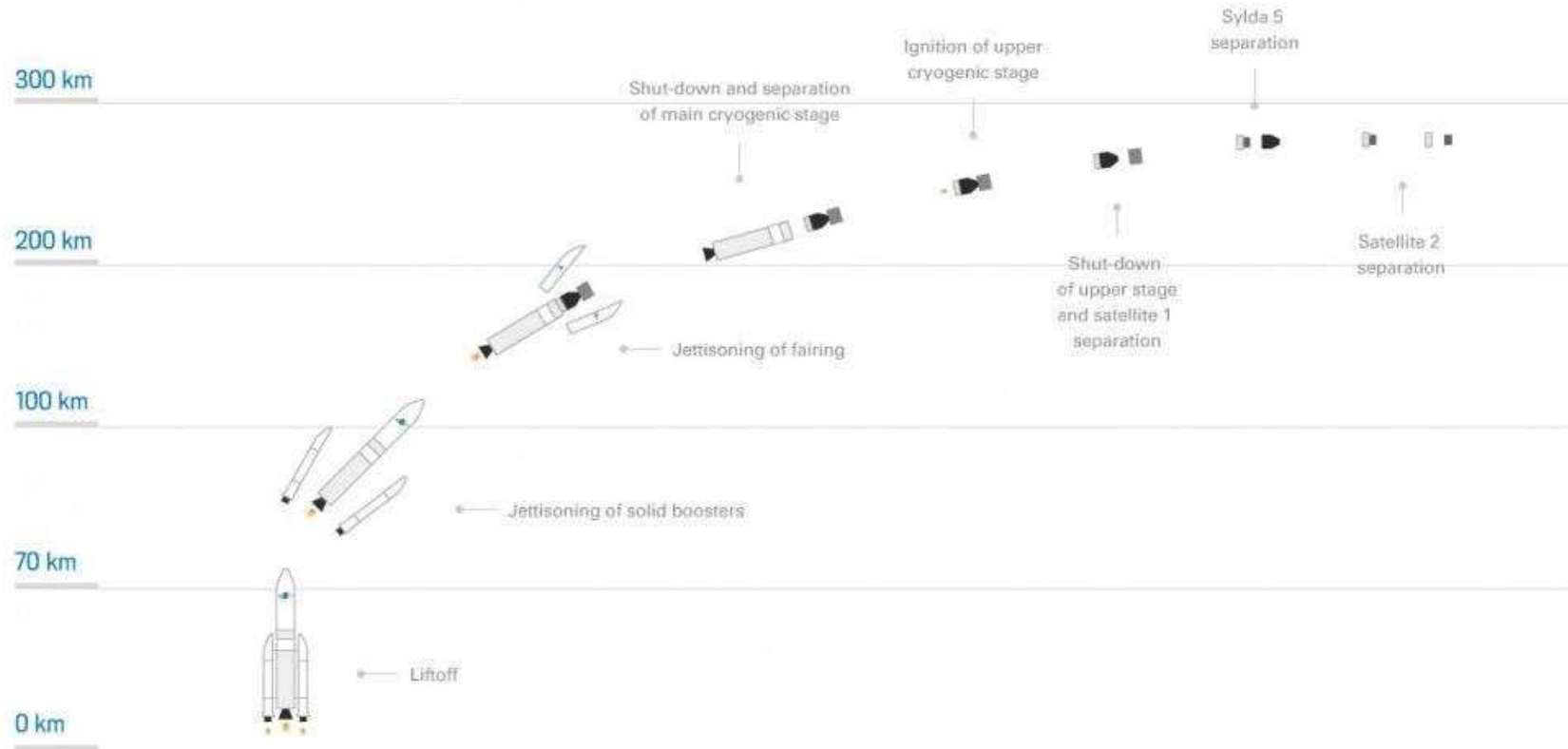
INTRODUCTION



- Heavy-lift space launch vehicle
- Developed and operated by ArianeSpace for the European Space Agency (ESA)
- Delivers payloads into orbit (10-20 metrics tons)
- Total launch price (max 2 satellites) = 150 million euro (2015)

- Height: 50.5m
- Weight: 780t

STANDARD MISSION



FIRST MISSION



On June 4th, 1996, just 37 seconds after its launch, Ariane 5 flipped 90 degrees in the wrong direction

An abrupt course correction was made, compensating for a wrong turn that had not taken place





COST

One of the most expensive bugs in history!

- ~ 370m dollars
- Public inquiry
- Destruction of the rocket's payload (delayed scientific research ~4 years)

WHAT HAPPENED?

```
L_M_BV_32 := TDB.T_ENTIER_32S ((1.0/C_M_LSB_I
                                G_M_INFO_I
if L_M_BV_32 > 32767 then
  P_M_DERIVE(T_ALG.E_BV) := 16#7FFF#;
elsif L_M_BV_32 < -32768 then
  P_M_DERIVE(T_ALG.E_BV) := 16#8000#;
else
  P_M_DERIVE(T_ALG.E_BV) := UC_16S_EN_16NS(T
end if;

P_M_DERIVE(T_ALG.E_BH) := UC_16S_EN_16NS (TDB
                                ((1.0/C_M
                                G_M_INFO_I
end LIRE_DERIVE;
```

Software exception in the alignment part of the Inertial Reference system.

64-bit float -> 16-bit signed integer

The current velocity was too high to be represented as a 16-bit integer

Error handling was suppressed for performance reasons

HOW COULD THIS BE PREVENTED?

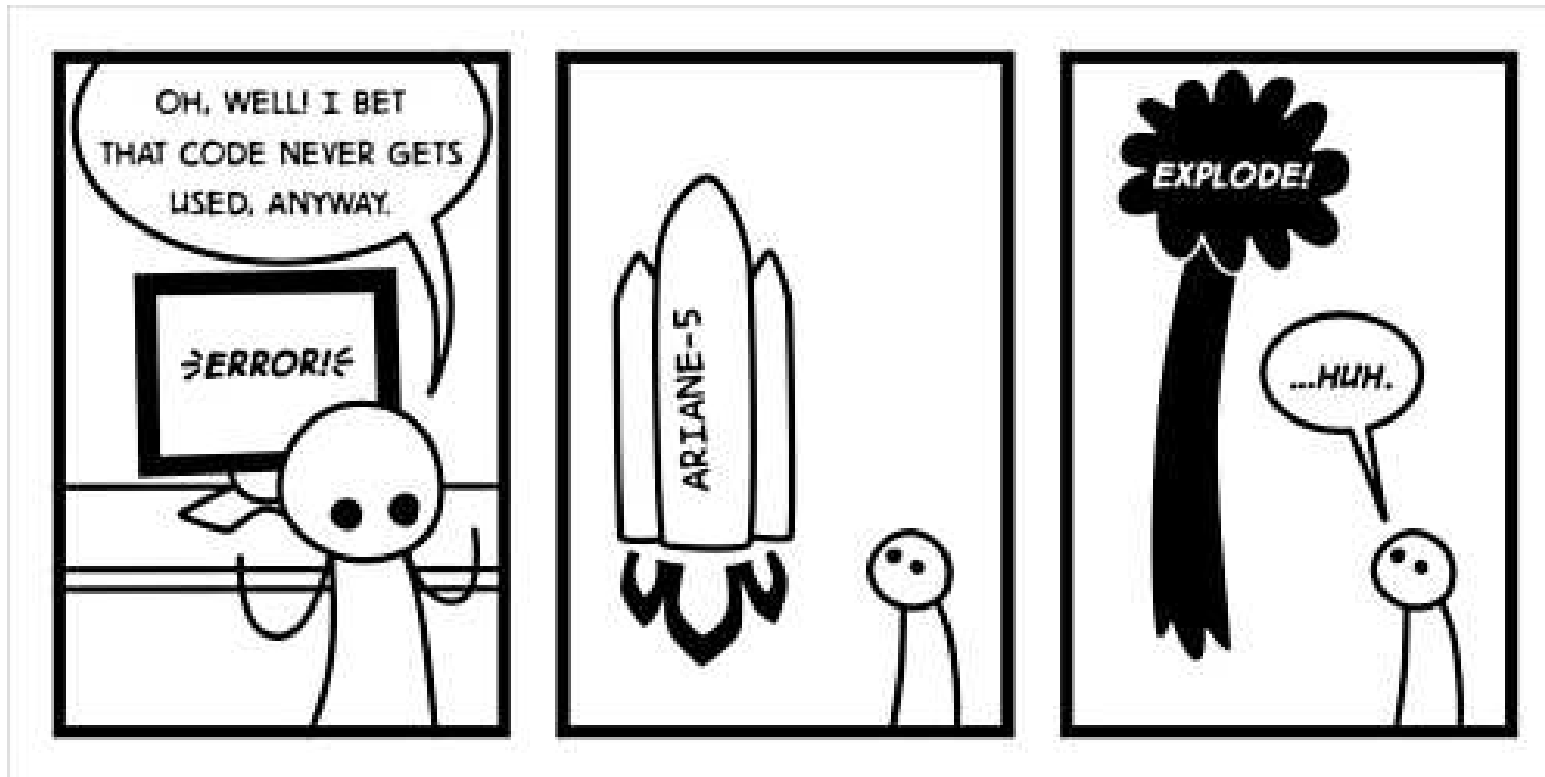


ORIGIN OF THE MALFUNCTION (3/3)



- **The fault could not be detected on the ground by any of the static or environment tests performed on the SRIs**
- **The error could have been detected in testing:**
 - **on the software alone. A test of this kind was performed but unfortunately with an unsuitable choice of parameter**
 - **by simulating the Ariane 5 trajectories through electronic input to the SRI instead of the sensors. This type of simulation was performed at launcher level, but without actual SRI equipment**

THANK YOU!



Sources:

<https://medium.com/swlh/how-lines-of-code-made-a-rocket-explode-77df73deb0a4>

<https://www.arianespace.com/vehicle/ariane-5/>