TOOL FOR REAL-TIME PREDICTION OF IXV TRAJECTORY IN THE MISSION CONTROL CENTER

Martins Sudars, Francesco Santilli (TAS-I)
Ivano Amador Caddeo (GMSpazio)
Gerhard Billig, Salvatore Mancuso (ESA)

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IXV Key facts

Agency: ESA
Prime: TASI

L/D ≈ 0.7

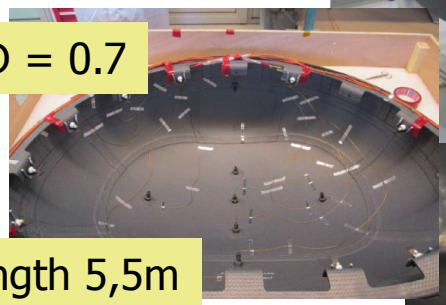
Weight 1840kg

Ceramic and ablative TPS

>40 partners

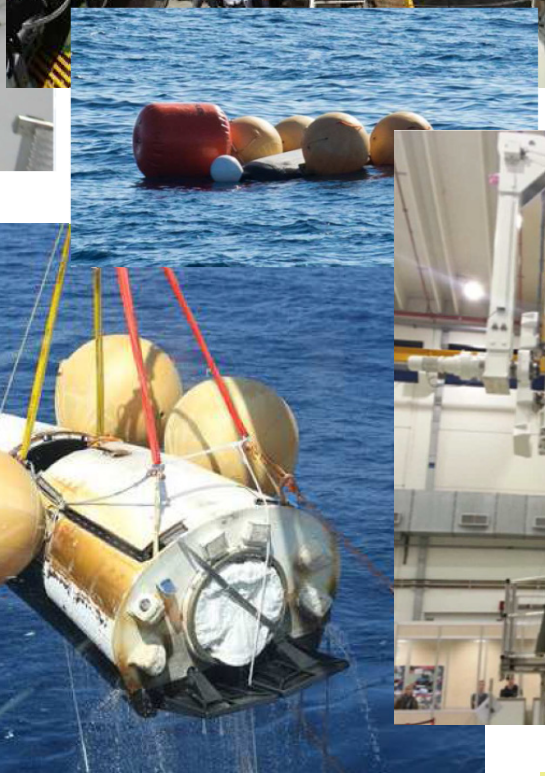
LEO Re-entry representative

L/D = 0.7

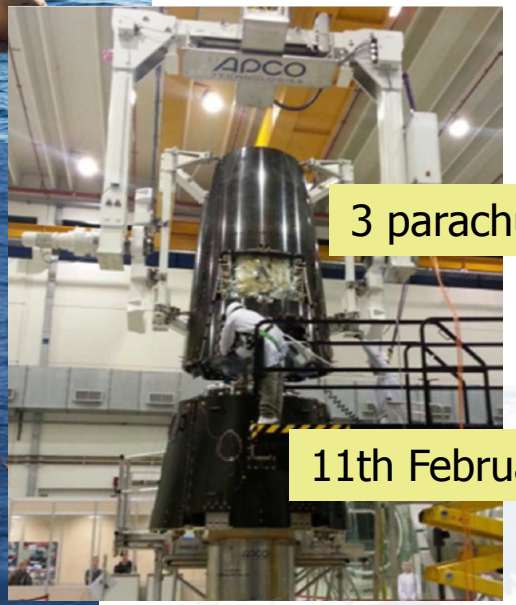


Length 5,5m

Launched by VEGA from Kourou

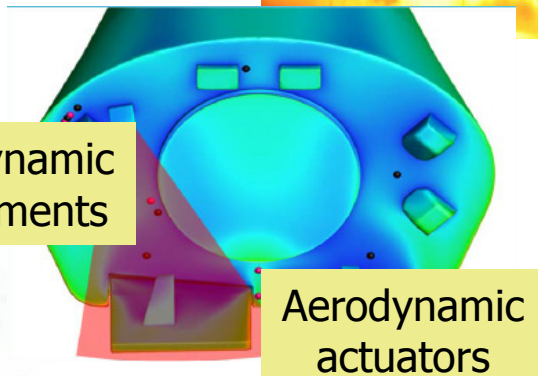


3 ground stations



3 parachute stages

11th February 2015



Aerodynamic experiments

Aerodynamic actuators

Recovered in SE Pacific

Guided entry

Images: Courtesy of ESA and TASI

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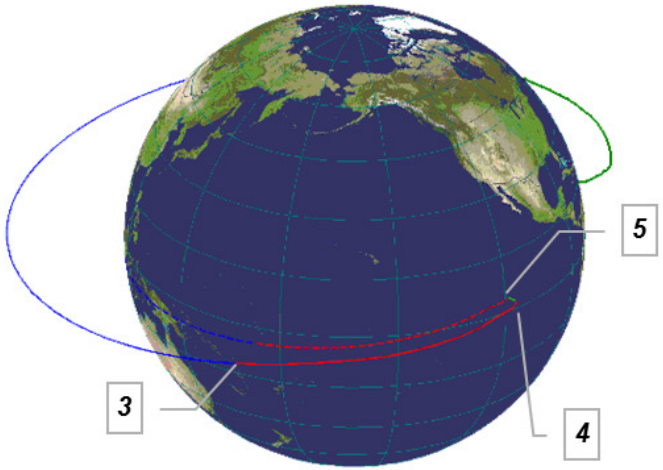
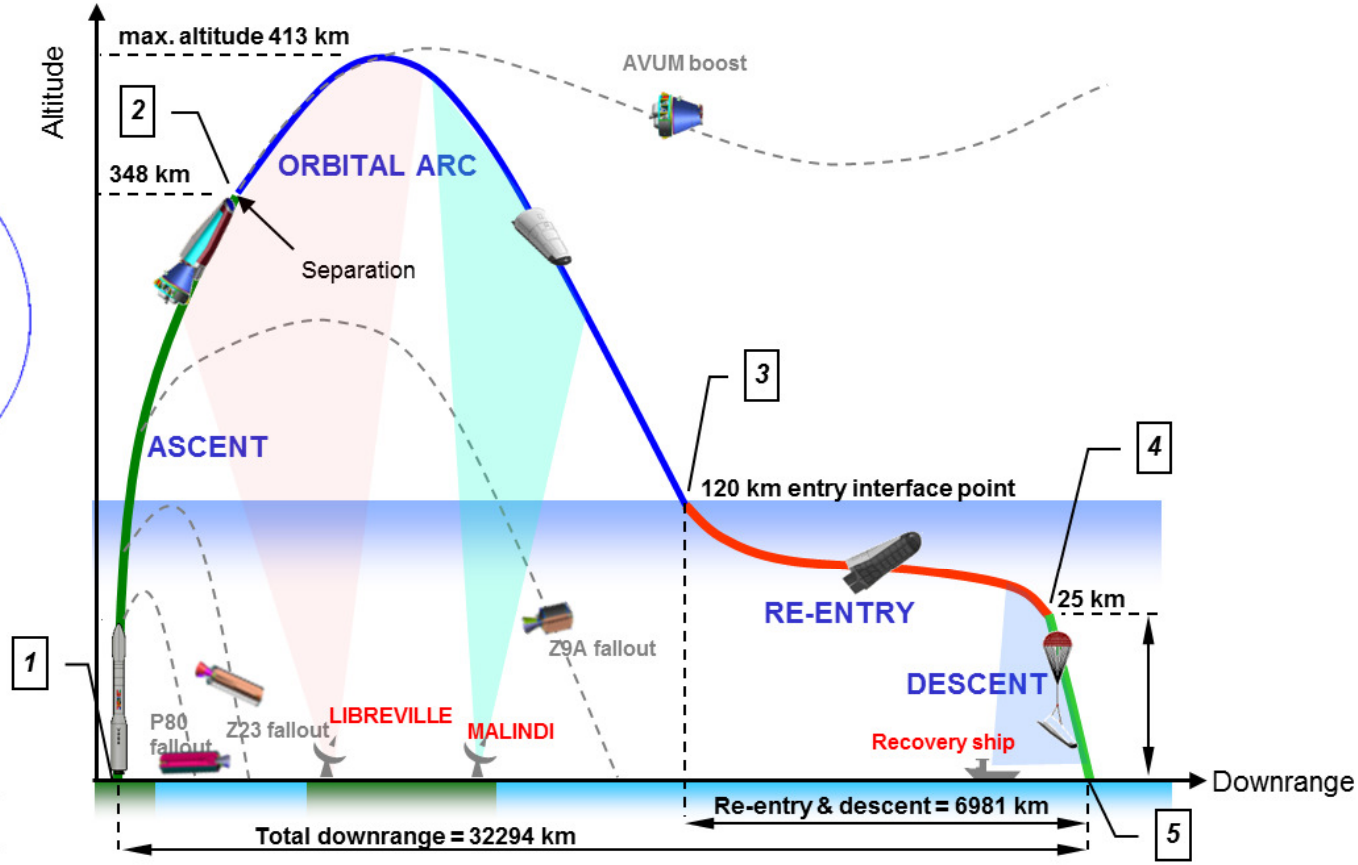
IXV Mission Profile

Reference Trajectory 3D view



[Altitude scale: 10X]



Reference Timeline

1 – Lift off	T = 0 [s]		
2 – Separation	T = 1130 [s]	⇒ *Ascent segment*	*1130 [s]*
3 – Entry gate	T = 3899 [s]	⇒ *Orbital segment*	*2769[s]*
4 – Descent gate	T = 5112 [s]	⇒ *Re-entry segment*	*1213 [s]*
5 – Splashdown	T = 6105 [s]	⇒ *Descent segment*	*685 [s]*

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IXV Mission Profile

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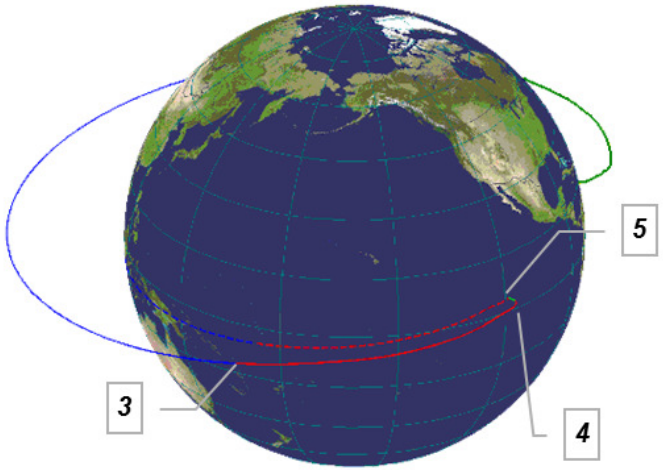

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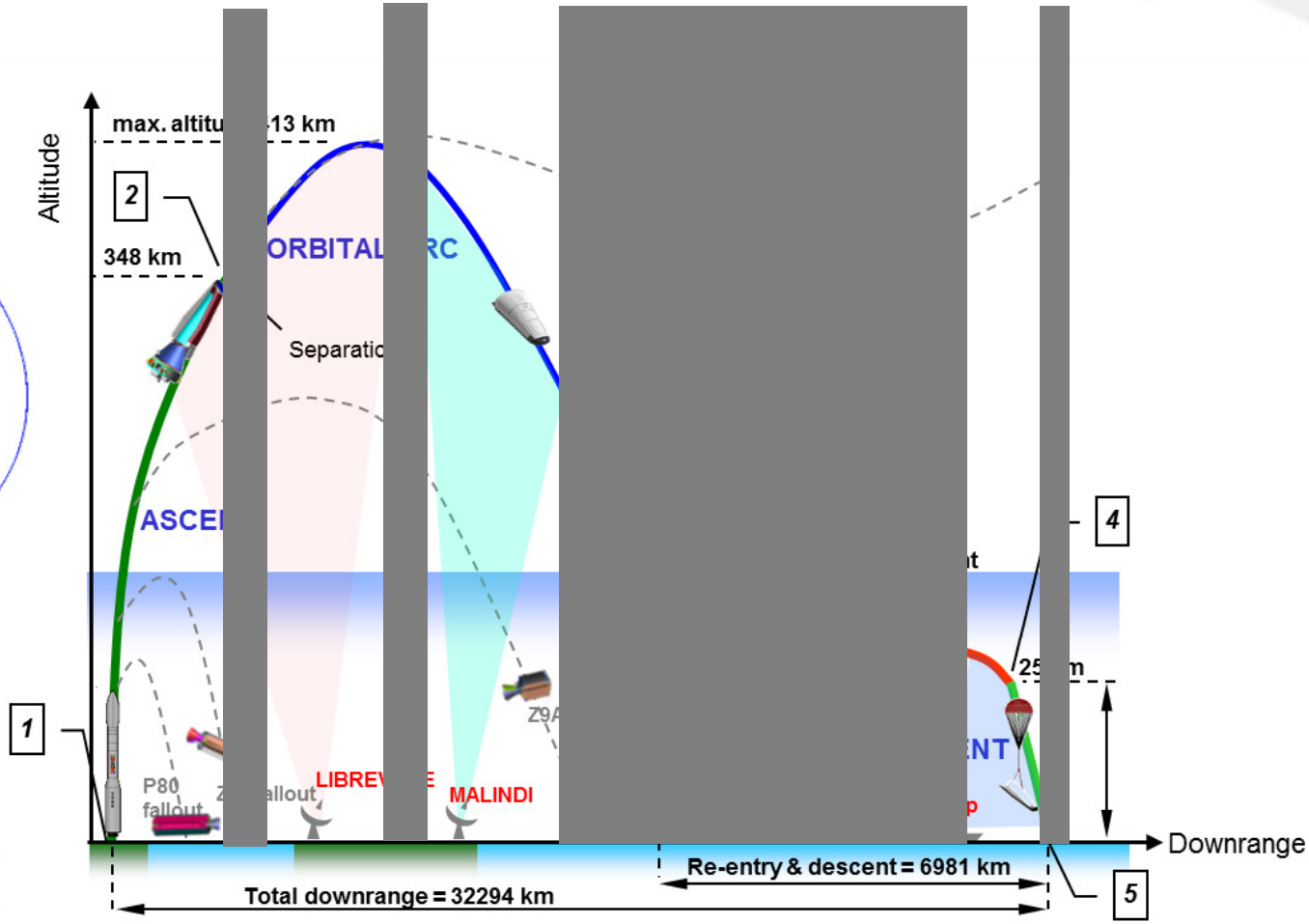

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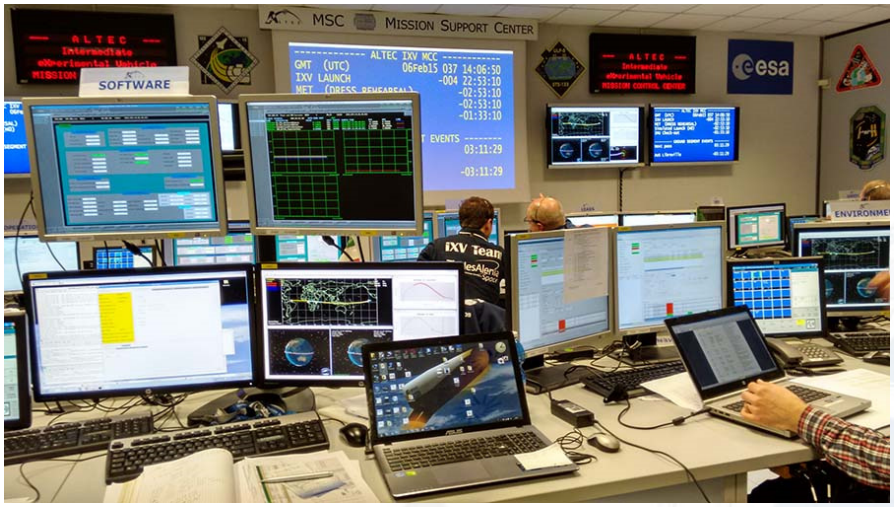
Trajectory Monitoring needs in the Mission Control center

- Monitor vehicle's startup and prelaunch events by TM
- Monitor vehicle's state during the flight by TM
- Propagate the trajectory and visualize for the operators
  - Including when out of visbility windows
- Provide the naval ground station with the pointing data (DO)
- Assist localization and recovery after the splashdown
- Monitor and predict vehicle's state in case of anomalies

IXV MCC during the mission



TPVT and GNC Consoles in foreground

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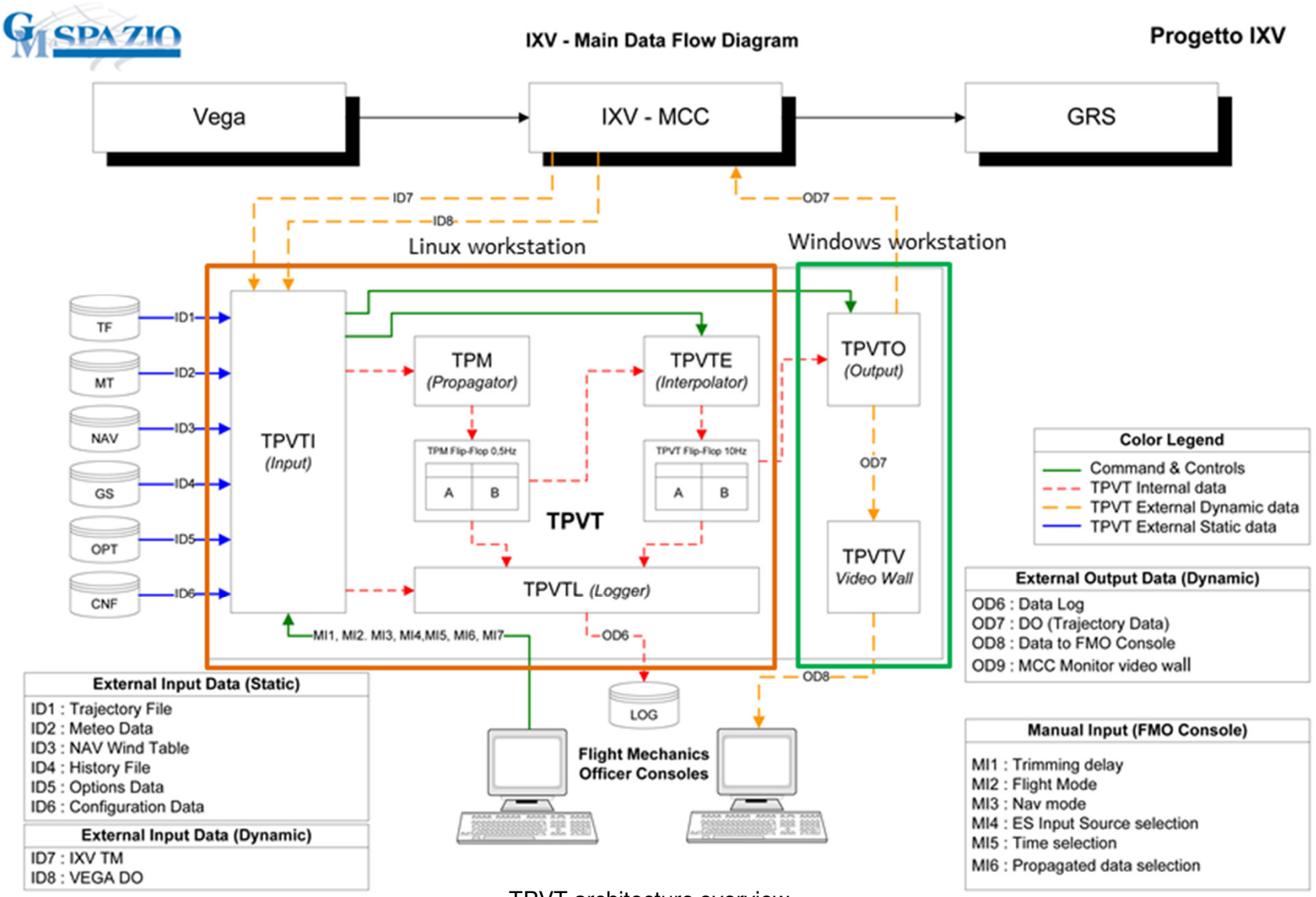
TPVT introduction

- TPVT = Trajectory Propagation and Visualization Tool
- Dedicated development
- An efficient and low cost solution was put in place
  - Development of a dedicated propagation core and graphic user interface
  - Visualization based on STK visualization engine
  - Running on commercial workstations in MCC
- Propagates trajectory from the actual point until splashdown whenever a fresh TM is available from IXV or VEGA
- Transmits vehicle's predicted state at 10Hz, updates the trajectory at 0,5Hz

TPVT architecture and dataflow



TPVT architecture overview

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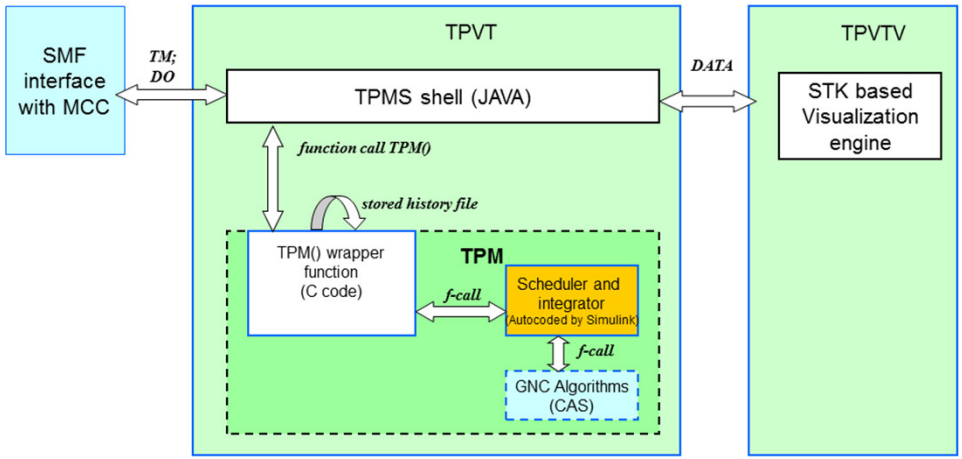
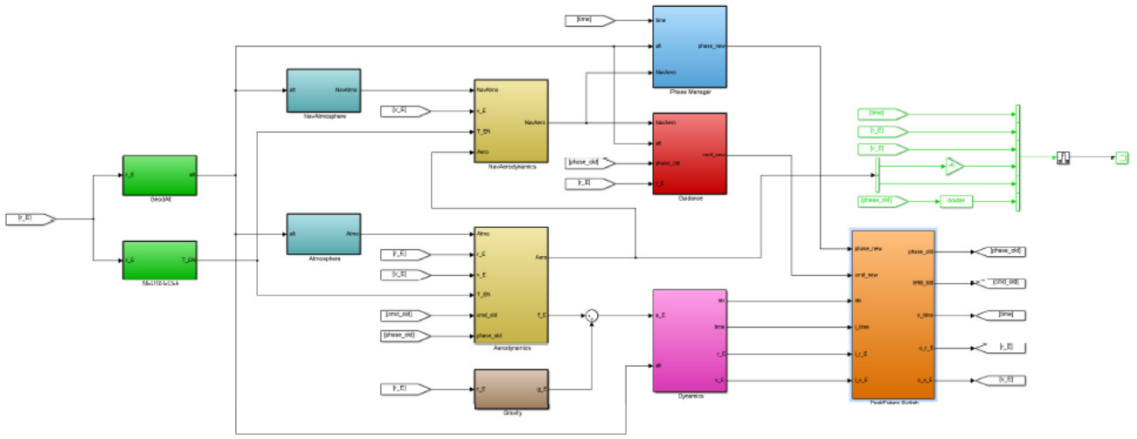
Propagator module (1/2)

- Development
  - Developed in Simulink,
  - autocoded and compiled and integrated as Dynamic Link library
- Features:
  - 3DOF propagation in Cartesian reference frame
  - Aerodynamic and environment models the same as used for IXV development, updated environment profiles uploaded from soundings
  - Guidance algorithms and parameters the same as for real IXV



TPM and it's internal and external interfaces



Simulink model of TPV

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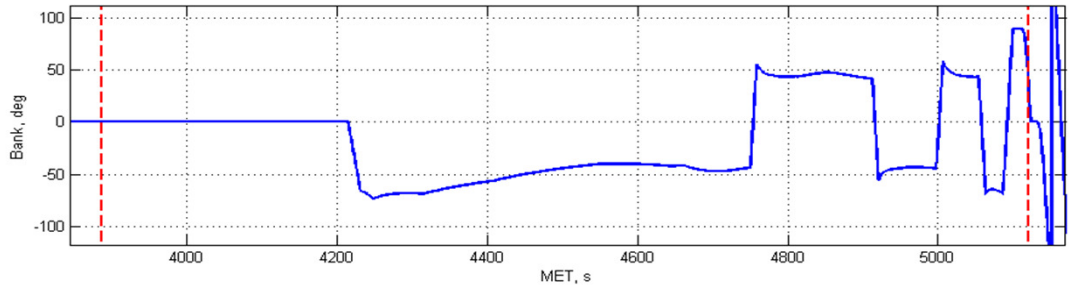
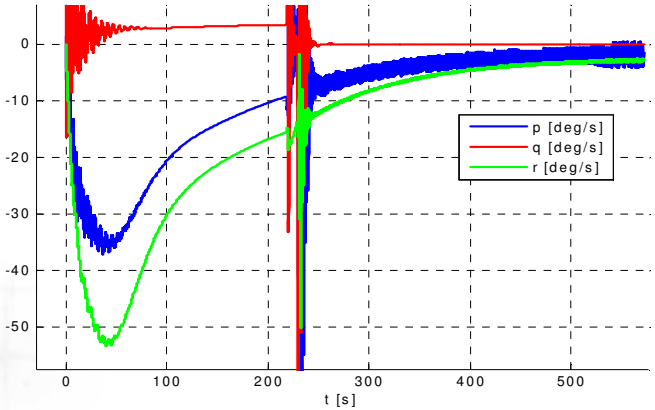
Propagator module (2/2)

- Output of the TPM: trajetcory profile until splashdown
- The closed-loop guidance opf re-entry outputs bank profile:

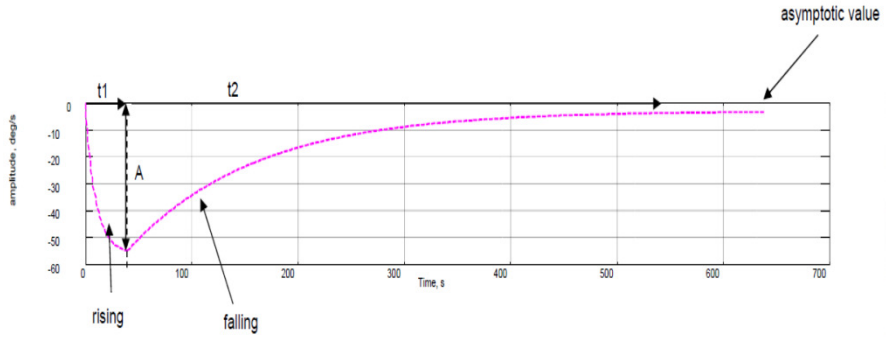


Bank profile generated by the guidance

- Dedicated attitude performance model has been developed for the desent phase, based on bank angle and roll/yaw rates



Behavior as simulated by 12DOF Multi-body simulator



Model used to approximate the bank rate under supersonic drogue

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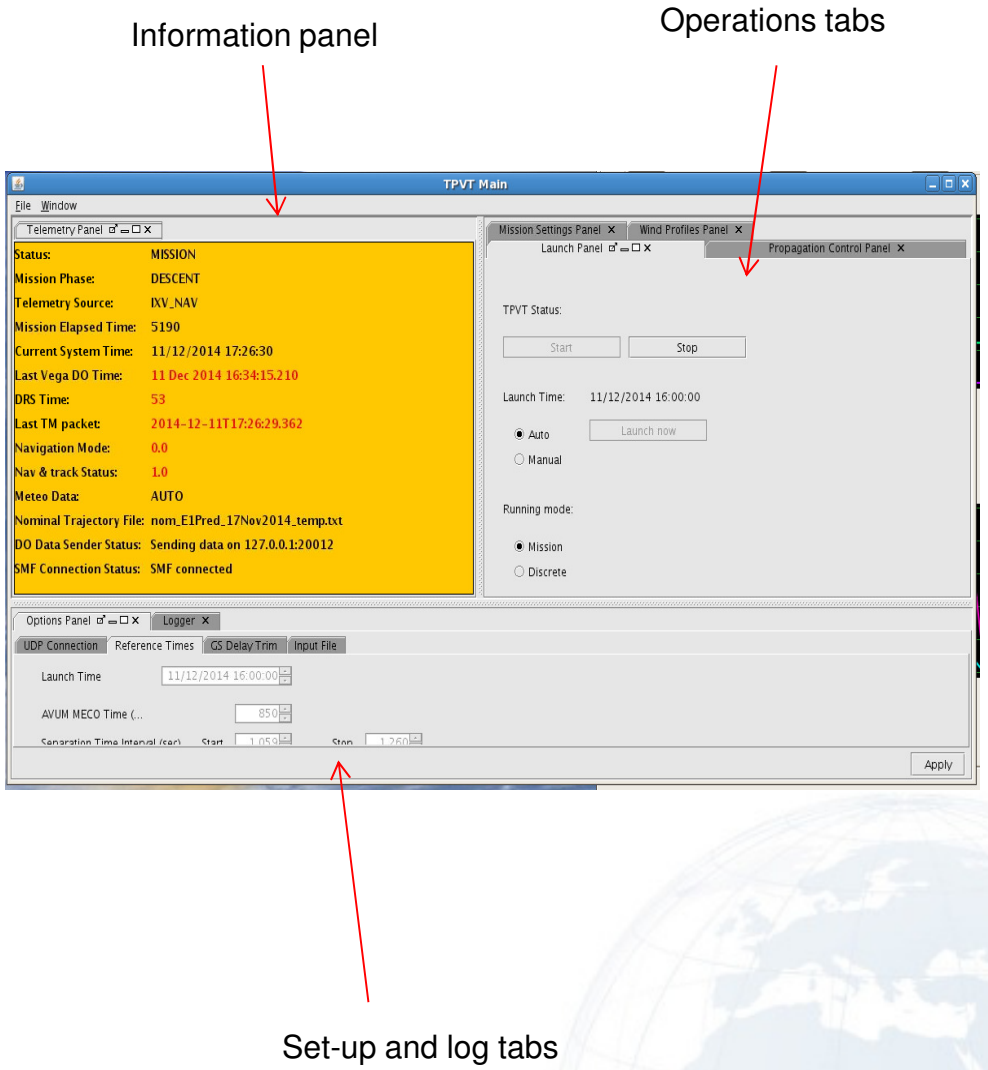
Graphic user interface

- Based on JAVA
- GUI functions and features
  - Monitoring of main events
  - Start/stop operations
  - Load trajectory and meteo profiles
  - Configure network settings
  - Trim network delay
  - Set launch time
  - Manually select mission phase
  - Manually select TM source
  - Manually introduce initial conditions (from FAX, or GNC MIMCS)



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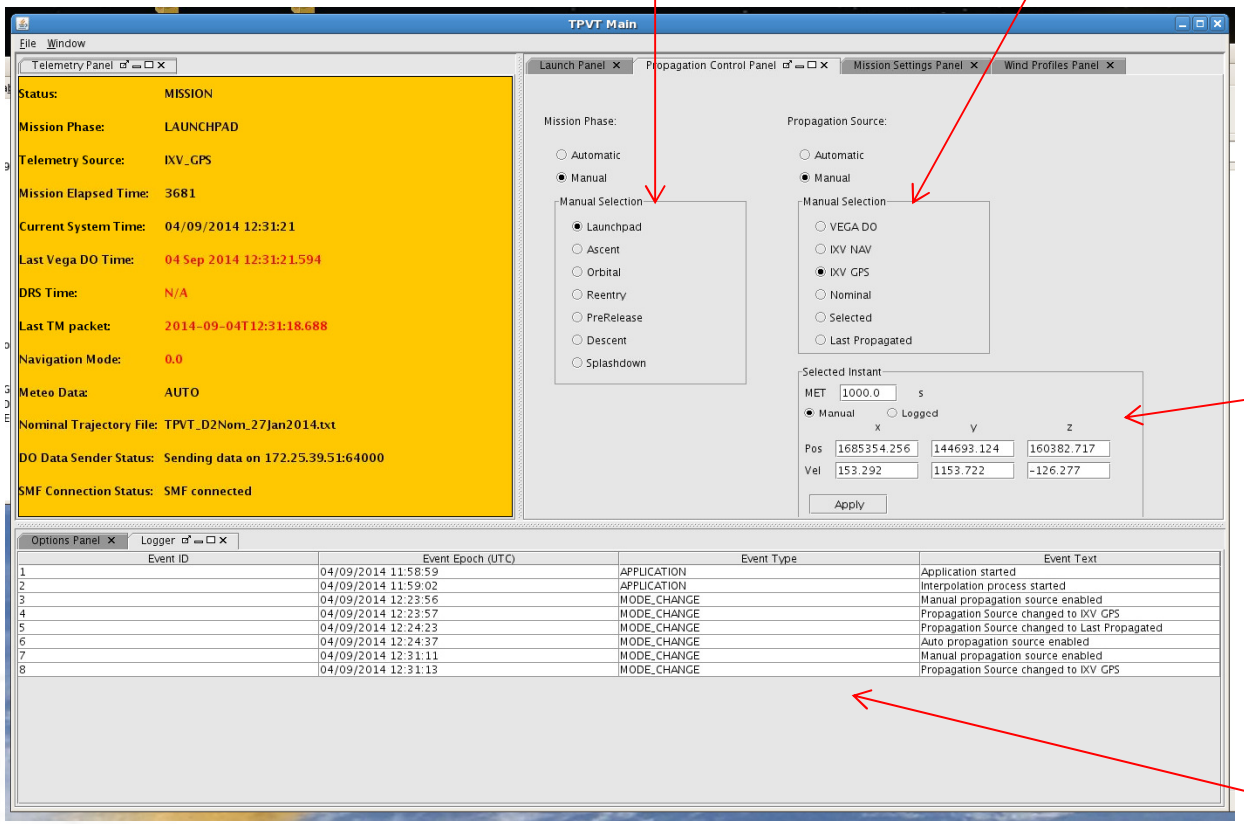
Graphic user interface

Example of GUI windows

Phase selector Propagation source



Manual initial conditions

Event's log

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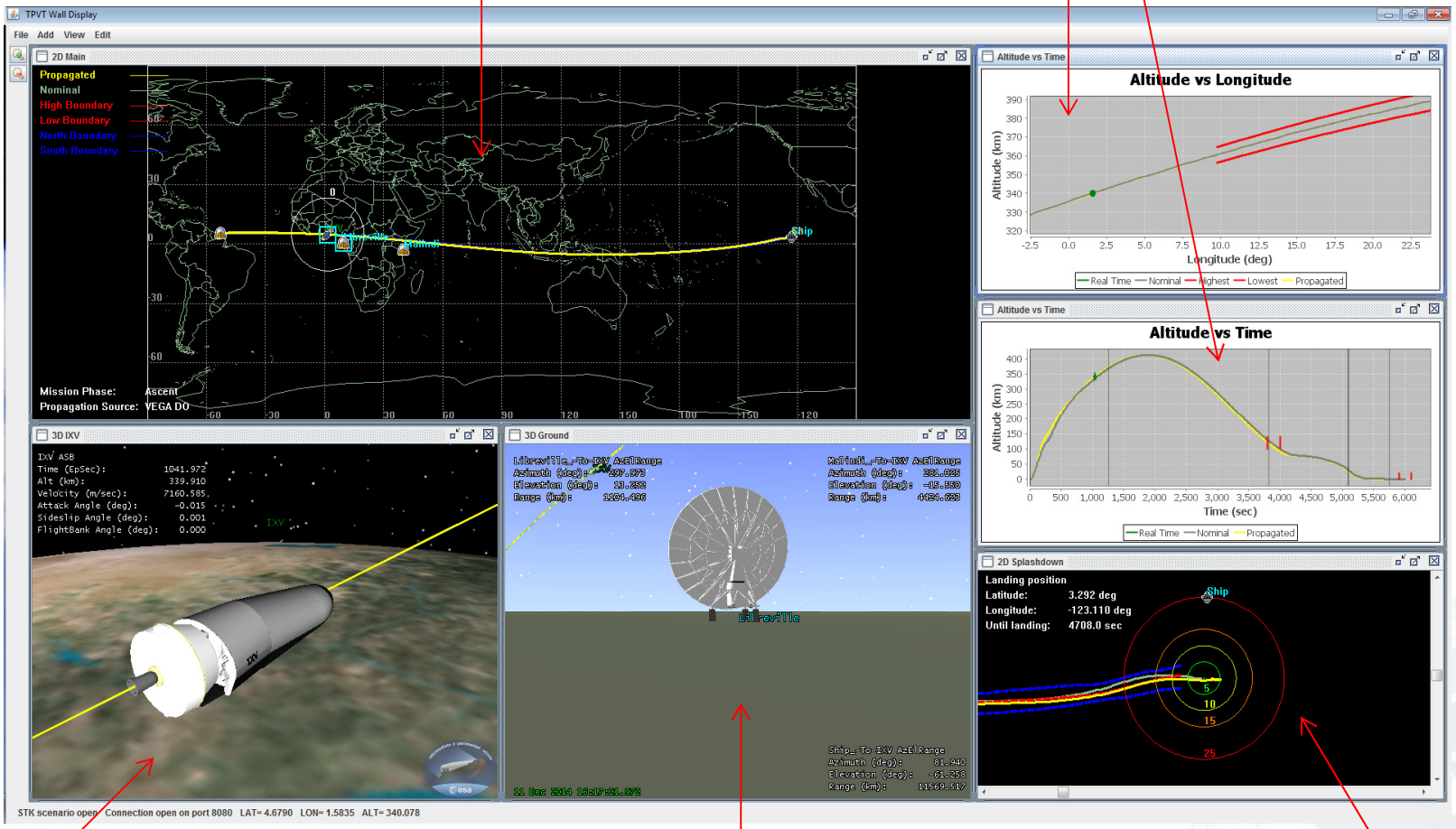
Visualization features

2D globe map

Downrange and time information



3D attitude

Visibility from antennas

Splashdown area

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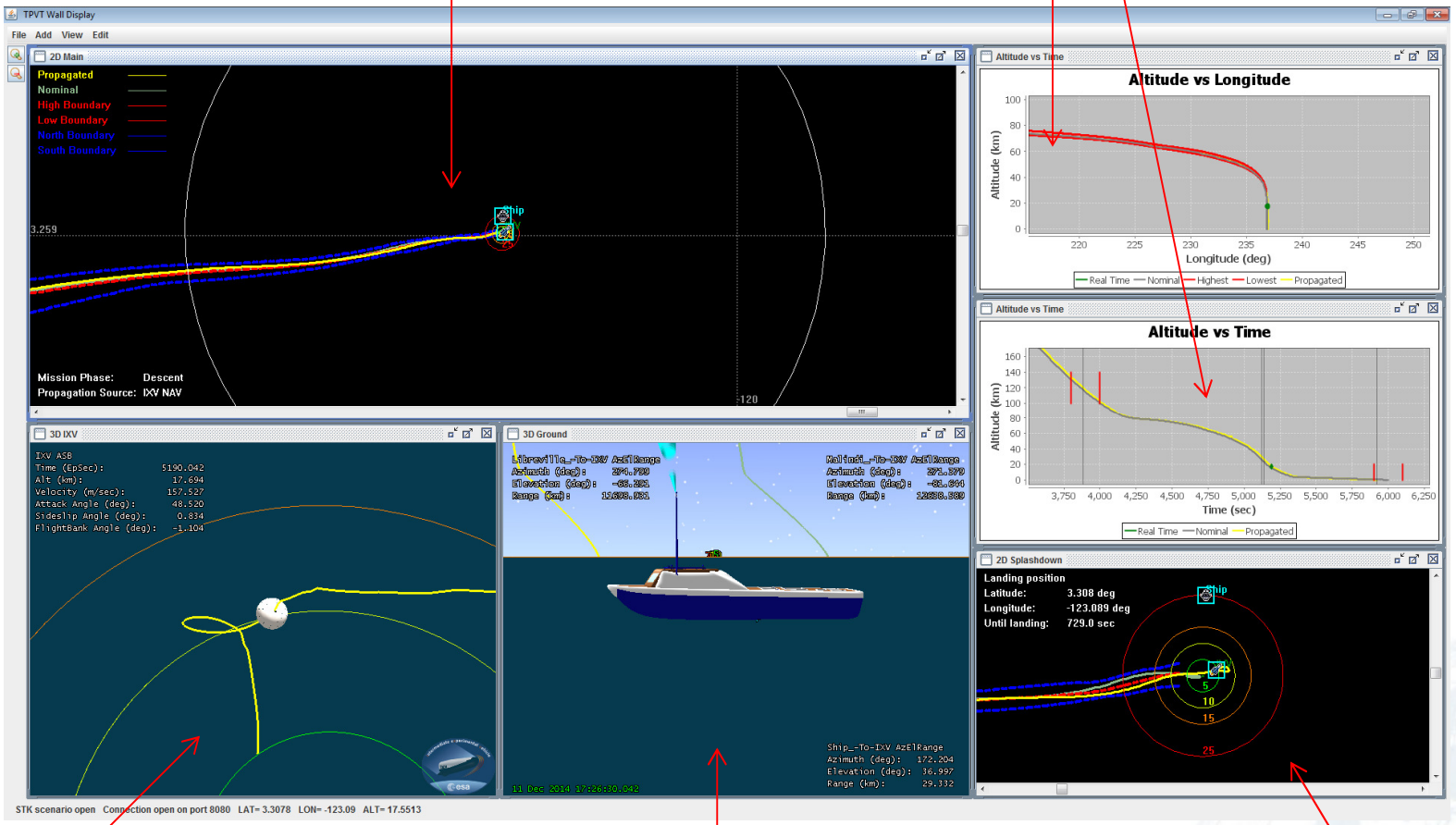
Visualization features

2D globe map zoomed

Downrange and time information



Vehicle under parachute

Visibility from ship

Splashdown area

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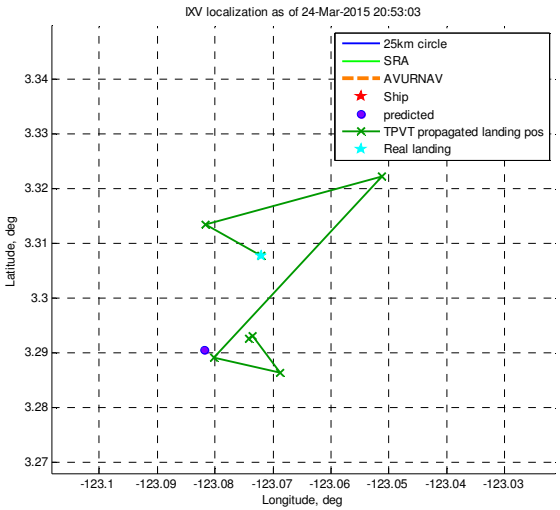
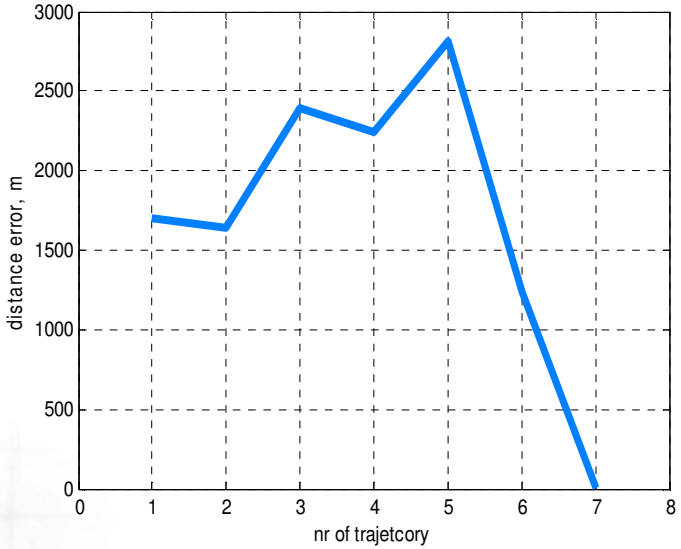
Propagation performance

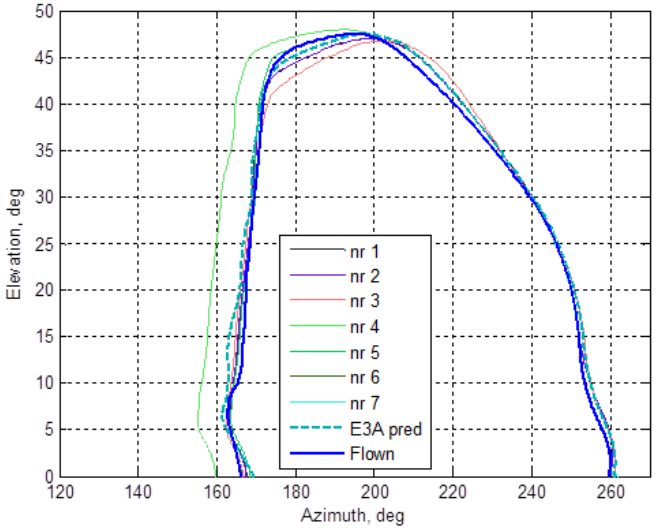
- Analyzed for selected points:
  1. 1st VEGA DO packet
  2. last VEGA DO packet, before IXV TM became available
  3. first packet after separation
  4. last packet before Malindi LoS
  5. 1st packet after NAVAL AoS
  6. 1st packet after DRS triggering
  7. Last received packet



Predicted splashdown position together with the 25km circle (accuracy requirement), SRA and NOTAM/AVURNAV area



Distance error (between propagated and real vehicle's splashdown point)



Azimuth elòevation profiles for tyhe propagated trajectories

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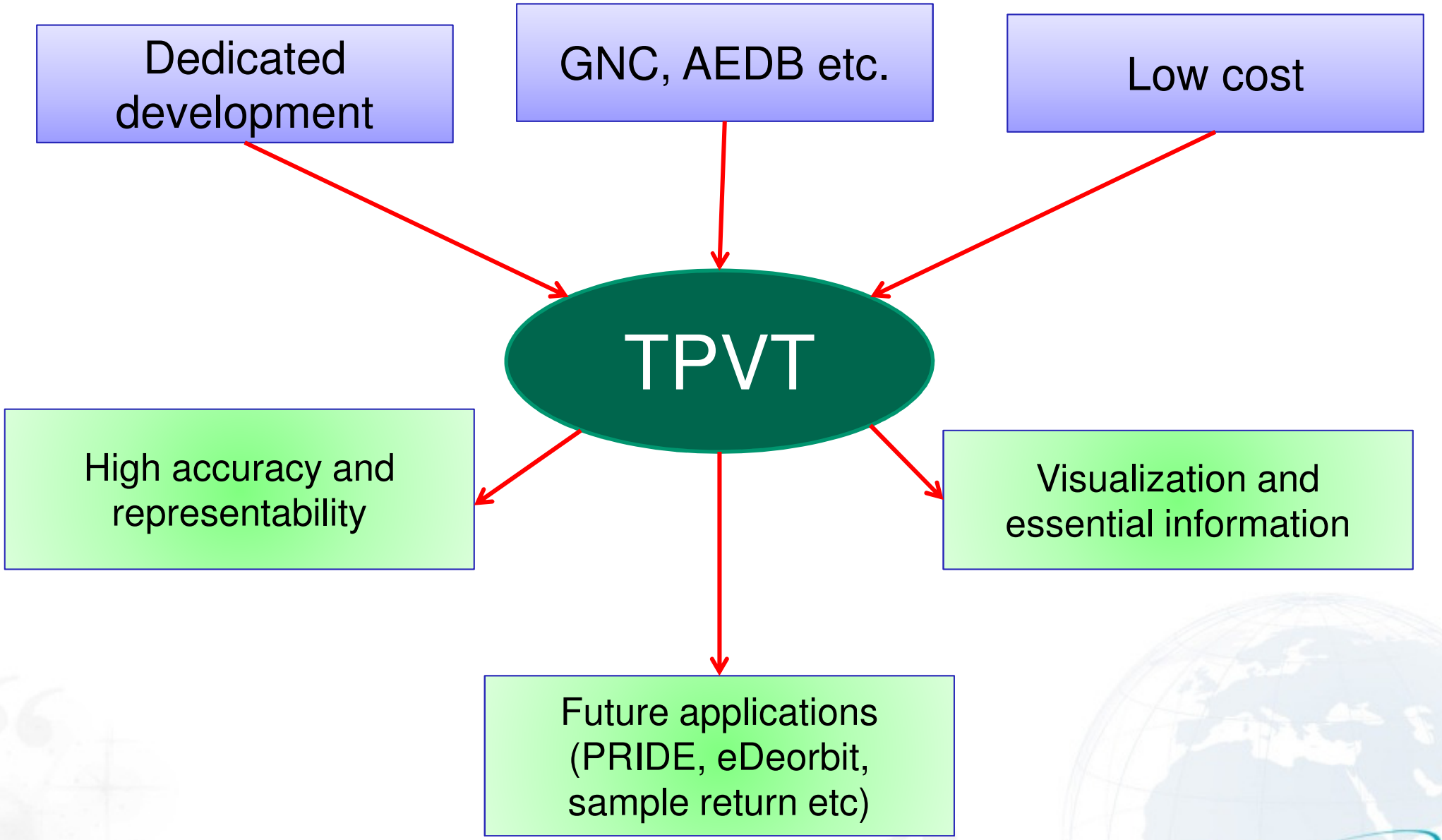
Conclusions



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15 hours in 2 minutes!

Thank you!!!

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