



DLR-Institute of Flight Systems

On-going and new projects

Outline

- ▶ **A²STRA – DLR's new Flight Test Aircraft**
- ▶ **Shex 2 – Sharp Edge Flight Experiment**
- ▶ **FASTWing CL and MiTraPor - Air Drop of Heavy Loads**
- ▶ **Human-Machine-Interface for Manned-Unmanned Teaming
(Scientific Exchange Program between US Air Force and DLR)**
- ▶ **PhD on Model Predictive Control
(Cooperation between CTA, Brasilia and DLR)**

A²STRA – DLR's new Flight Test Aircraft



DLR - A320 Aviation Technology Demonstrator

A²STRA = Airbus A320 Simulation Test and Research Aircraft



Background Information #1

- ▶ **Since 1986 ATTAS is in operation at DLR Braunschweig**
- ▶ **In-flight technology demonstration since 30 years**
- ▶ **Last operated VFW 614 aircraft, no industrial support anymore**
- ▶ **End of ATTAS operation expected within the next 2-3 years**
- ▶ **In September 2005 a project team was initiated to start the procurement of an appropriate aircraft as successor of ATTAS**



Background Information #2

▶ **Selected Aircraft:**

- A320-232, MSN 659,
- year of construction 1997,
- IAE V2527-A5 engines,
- operated by FlyNiki until March 2006.

▶ **Final decision for procurement in March 2006.**

▶ **Delivery and first official presentation in June 2006.**

▶ **Aircraft operation in Braunschweig: runway extension and hangar concept in progress.**

▶ **Airbus-DLR cooperation agreement for the next two years envisaged.**

A²STRA - Research Objectives

- ▶ Definition and implementation of technical modifications in close cooperation with Airbus.
- ▶ Long term research cooperation with Airbus.
- ▶ Integration into European Clean Sky JTI.

Non-exhaustive list of research topics:

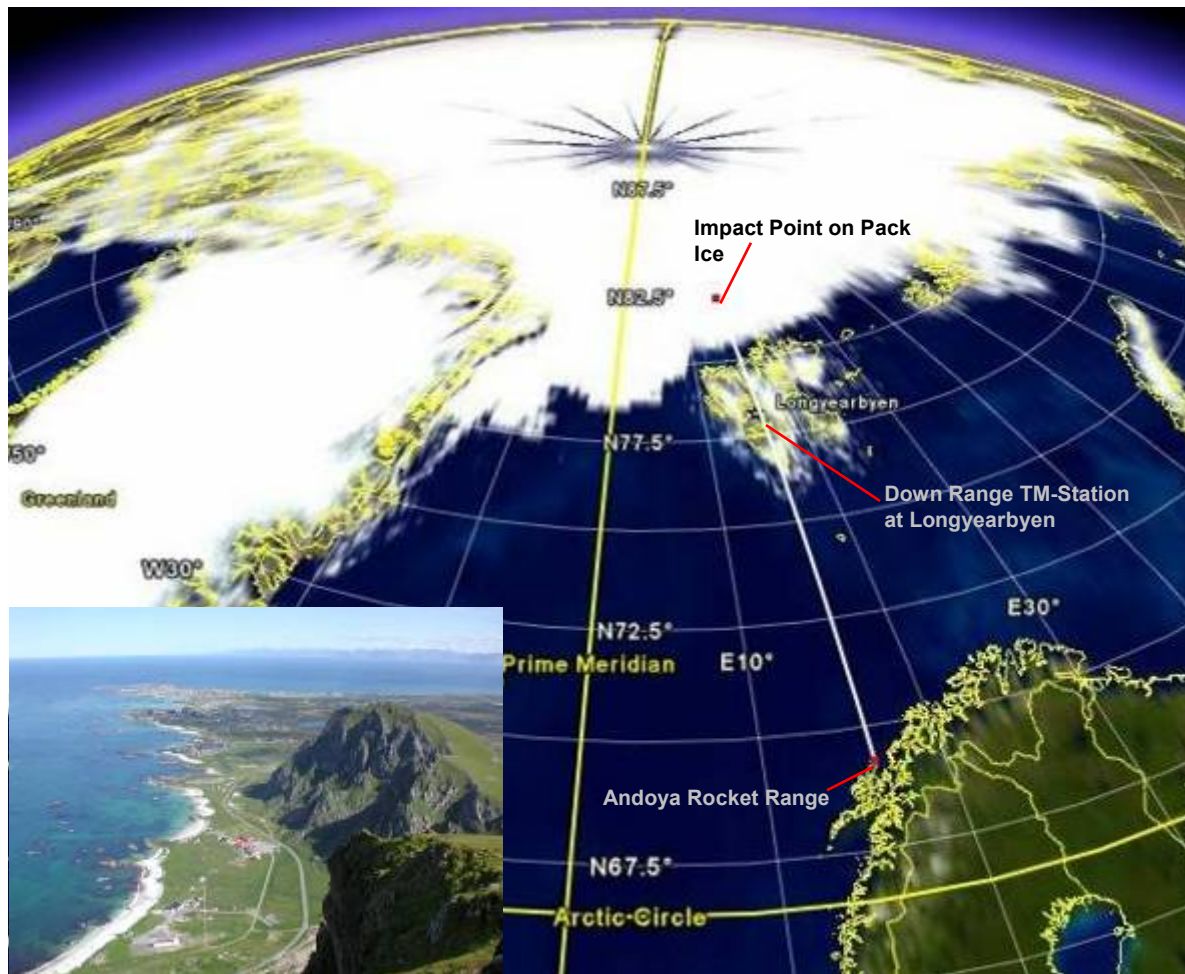
- ▶ Advanced In-Flight Measurement Techniques,
- ▶ Air Traffic Management,
- ▶ Human Machine Interface,
- ▶ Controlled Flight into Vortex,
- ▶ Advanced High Lift Systems.

SHEFEX 2

- ▶ **Sharp Edge Flight Experiment**
(Objectives: Proof of concept, validation of aero-thermodynamic data)
- ▶ Hypersonic flight experiment, active control via canards / fins
- ▶ TPS-Experiment, symmetrical faceted forebody (8 identical segments)
- ▶ Velocity > Mach 13 to 7 during reentry
- ▶ Experiment phase between 90 and 20 km altitude on downleg
Low reentry angle → experimental time 45 to 65 sec
- ▶ Recovery of experiment vehicle
- ▶ Possible re-use of components/technologies of SHEFEX 1

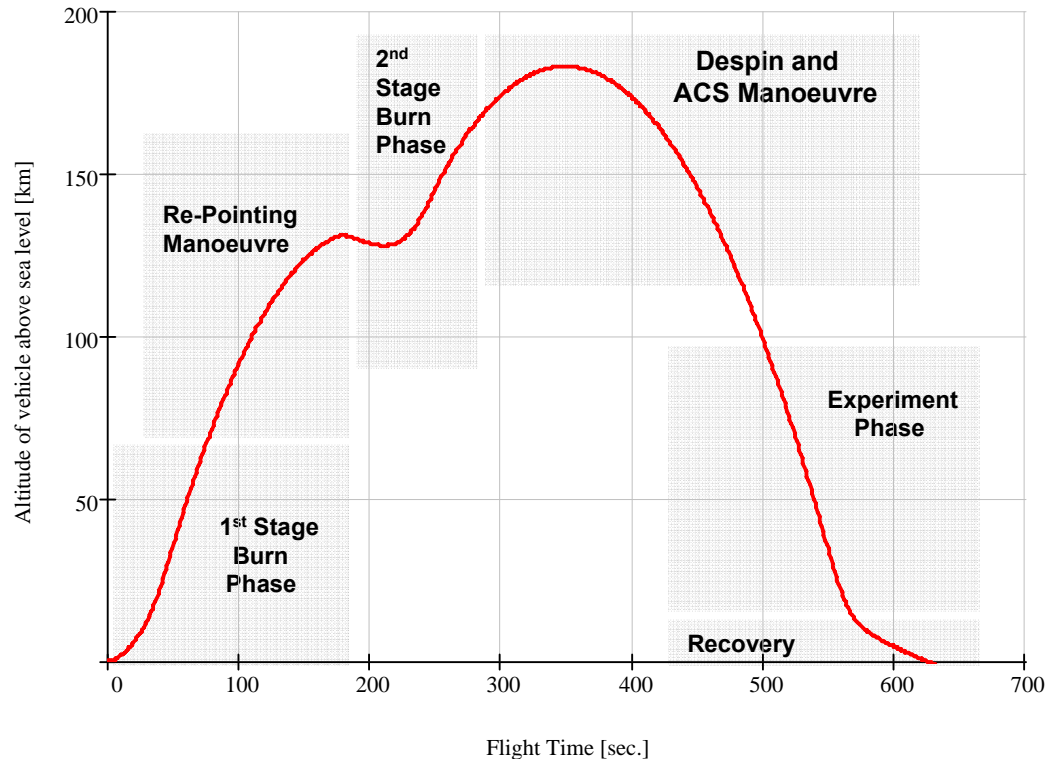


Preliminary Mission Scenario



- ▶ Start at Andoya Rocket Range, Norway
- ▶ Fly over Svalbard Island
- ▶ Landing ca. 400 km north of Svalbard on ice
- ▶ 'Land' recovery

Preliminary Trajectory and Events (1)



- ▶ Apogee 180 km
- ▶ Minimum ground range 1230 km
- ▶ Re-pointing of 2nd stage and nearly horizontal ignition (0 deg)
- ▶ Despin and ACS maneuver for experimental phase
- ▶ Experiment phase from 100 to 20 km
- ▶ Recovery

VS-40 Vehicle and SHEFEX 2 Experiment (Draft)



- ▶ Estimated P/L mass 350 kg
- ▶ Estimated P/L length 5500 mm

Research Agenda for DLR Braunschweig

- ▶ Flight mechanics modeling and analysis
- ▶ Design of flight control system
- ▶ Design of actuation systems
- ▶ Selection of on-board computer
- ▶ Development of Hardware-In-The-Loop-Simulation
- ▶ Systems and algorithms for Flush Air Data System (FADS)
- ▶ Flight data analysis and support of test campagne

EU-Project – FASTWing CL

► Motivation & Objectives

- Development of a self-guided parafoil/payload system for cargo up to 6.000kg
- Successor of FASTWing which was completed in June 2005

► Partners

- Autoflug (Coordinator), CIMSA, CESA, CFD Norway, DLR, Dutch Space, NLR, Technion

► Work Packages (DLR)

- Data Acquisition & Evaluation
- Video Analysis
- Modeling & System Identification
- Fault Tolerant Control Algorithms

► Schedule

- Kick-Off November 2006
- 3 Years

► Funding

- DLR 50% EU 50%



MiTraPor – Airdrop Related Activities

► Motivation & Objectives

- Development and validation of airdrop simulation models
- Multi-disciplinary simulation of airdrop missions

► Work Packages

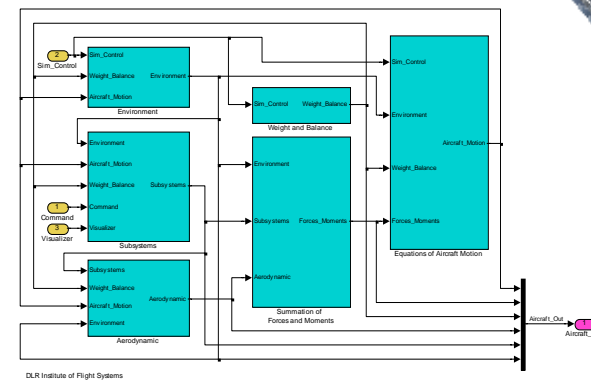
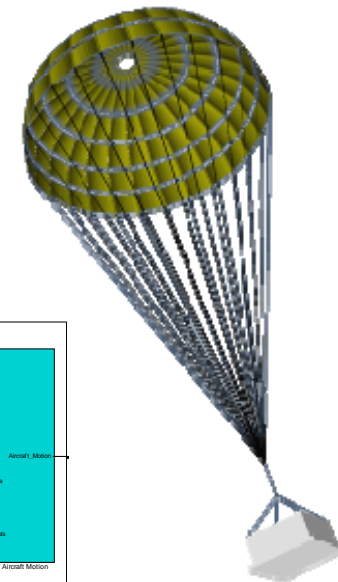
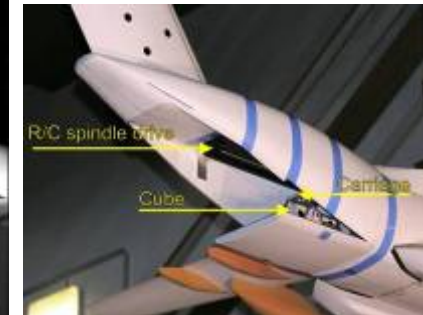
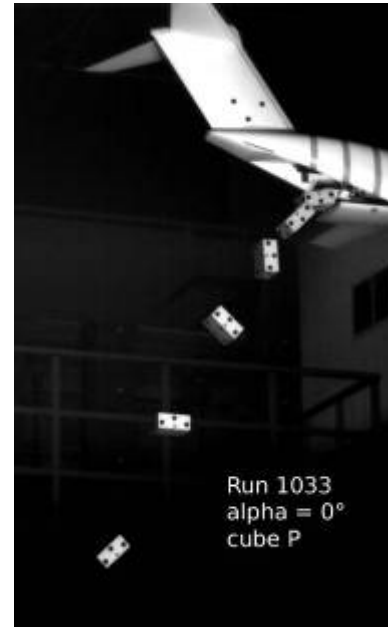
- Simulation environment
- Wind tunnel validation
- Multi-disciplinary simulation
- Mission analysis and evaluation
- Visualization

► Schedule

- Kick-Off July 2006
- 3 Years

► Funding

- DoD



HMI for Manned Unmanned Teaming

▶ Program

- Lt. John Casey
- Scientific Exchange Program between US Air Force and DLR

▶ Motivation & Objectives

- The MUM-T Challenge: How to control a UAV from a manned aircraft.
- Application: Military Helicopters + Electronic Wingmen
- Case Study with first demonstrations (FHS & ARTIS)



▶ Work Packages

- Interface Design for Crew Situational Awareness
- Direct Voice Input (DVI), Syntax and Applications
 - Voice Command Strategies currently under development
- Haptic Interface Design (Active Sidestick)
- Hardware-in-the-Loop Simulation and Flight Tests



▶ Schedule

- 07/2006-06/2008

Model Predictive Control

▶ Program

- Fabio Andrade de Almeida
- Cooperation between CTA and DLR

▶ Motivation & Objectives

- **Nonlinearities** exist in most of the modern flight control systems
 - Rate limiter, Hard limiter, Output constraints (flight envelope)
- Classic and modern control techniques does not take them into account
- Development and Certification tests seldom explores these limitations

▶ Some benefits of MPC in Aerospace Industry:

- Adaptability for control / aerodynamics / propulsion modifications
- Safe operation near flight envelope boundaries
- Open-loop strategy

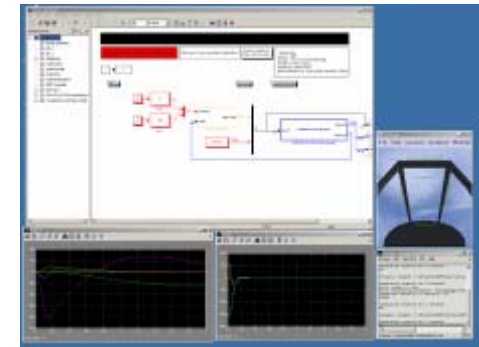
▶ Main challenges:

- On-board computational processing availability
- Nominal and robust stability
- Certification process

Model Predictive Control – Project Overview

Work Packages

1. **Research of MPC techniques (in progress)**
 - Infinite horizon approach is nominally stable
2. **Computational development of a basic MPC Controller (in progress)**
 - Finite and infinite horizon approach already running into ATTAS SIMULINK™ model
3. **MPC_basic simulation and analysis (in progress)**
4. **Implementation and tests of MPC_Basic into ATTAS ground simulator**
5. **Implementation of MPC_basic into ATTAS.**
6. **MPC_basic flight tests**
7. **Conceptual and development of new MPC strategies (MPC_add)**



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