SURVEY OF AGENCY PROGRAMMES AND BUDGETS DEDICATED TO DEMONSTRATION AND DEVELOPMENT AVAILABLE FOR GERMAN SPACE INDUSTRY

R. Pernpeintner, D. Sygulla MT Aerospace AG Franz-Josef-Strauß-Straße 5, D-86153 Augsburg Germany

OVERVIEW

Since the ESA ministerial conference in late 2005, the scattered landscape of space development approaches seems to be more transparent. The variety of investigation and development attempts has been assigned to distinct programmes for the near future, medium and long term periods. This applies to the scientific scene as well as to the launcher related market. Besides the decided ESA themes as EOEP, TRP and GSTP, headlines as FLPP, ACEP, ARTES, Exo-Mars, GMES, Aurora and Clipper (CSTS) have become drawers for various single topics within them.

On the other hand, new necessities of investigation emerge, like Ariane 5-mid life (A5-ML). These programmes are making use of budgets already dedicated to others. In parallel, there is an eager national space programme with separate funds to pursue national interests.

The present report summarizes the different programmes heading for demonstration or development of specific space-related hardware or competences. Those directly in connection with launcher programmes (Ariane 5, Vega, Soyuz) are not reflected here.

1. GLOBAL SITUATION IN EUROPE

For the European Space activities – national as well as for international programmes – the different countries spend a different share of their budget to space affairs. Figure 1 outlines a total of 710 M€ all over the European countries, an amount slightly decreasing from the last years up to 2011, in which a total of 660 M€ is expected from today's point of view. (All values corrected to economic conditions 2007.)

Within the European context France is spending the highest amount for space programmes, followed by Italy and Germany. These three biggest contributions sum up to 75% of the total European amount.



IG 1. Total European expenses for civil space programmes

Comparing the European space budget to those of other agencies, The following figure depicts the budget of different space agencies. Summing up NASA's and US-DOD's expenses, the ESA budget is only 1/10 of the US, followed by Japan, China (with a relatively high unsecurity factor), Russia and India.



FIG 2. Space budgets of different agencies

Today, the main consumer of the budgets at launcher level is still Ariane 5. Although the necessary efforts are decreasing, together with the EGAS supporting programme it still needs half of the European launcher budget, followed by VEGA and Soyuz-at-CSG (Centre Spatial Guyane).



Compared to those, the future preparatory programme FLPP contributes only to a limited extent.

Extrapolating to future, i.e. post 2010, the launcher supporting programmes ARTA and Verta together with recurring expenses to maintain CSG in Kourou will need a constant budget. New evolutions, like Ariane 5 mid-life, and may be an FLPP-3 are supposed to fill up the budgets up to today's level.

For Germany, in 2005 approx. 890 M€ had been devoted for civil space programmes, whereas 71% of that was dedicated to ESA and EUMETSAT, 17% for national funded programmes and 12% for DLR-internal Research & Development programmes.



FIG 4. DLR Space budget in 2005

All these figures comprise only civil efforts; expenses for military-oriented space efforts are not included.

2. DEVELOPMENT AND DEMONSTRATION PROGRAMMES

2.1. ESA ministery conference 2005

The ESA council on ministery level met in 2005 in Berlin, in order to decide on the principally common space politics, on the continuation of current programmes, as well as the start-up of new developments. The ESA member states, incl. Canada as associated member, and the EC commission enhanced the concentration of the European space activities on R&D and the increase of the competitivenss of the European industry.

Figure 4 shows a break-down of the total decided budget to the different programmes, as well as their duration. Not included are programmes and budgets already previously decided, as ARIANE 5, VEGA, Soyuz, EGAS etc.

Of those programmes, only FLPP and ACEP are relevant for new developments and demonstrators.



Programme	Period	Budget
ACEP	2006 - 2010	3%
ARTA	2007 - 2010	9%
ARTES	2006 - 2010	11%
Aurora	2006 - 2009	2%
ELIPS 2	2006 - 2009	3%
EOEP 3	2008 - 2013	26%
Exomars	2006 - 2011	14%
FLPP	2006 - 2009	6%
GMES 1	2006 - 2008	5%
GSTP	2006 - 2008	5%
ISS expl2	2005 - 2008	10%
VERTA	2006 - 2010	5%
TOTAL		4.738 €

FIG 5. ESA programmes decided at Ministerial Conference 2005 in Berlin

2.2. FLPP-2

The Future Launcher Preparatory Programme FLPP was already created and launched with the ministerial conference in 2003. Its global objective is to prepare the technical elements for Europe's next generation launcher, to be developed starting with year 2014 and to be qualified in the beginning of the next decade.

For the performance of the programme it was decided to create a new, independent prime contractor, the NGL Prime S.p.A., located in Torino, who should handle and distribute all the contracts from ESA on FLPP. This company is acting since the beginning of the FLPP.

The investigations to be performed in the first phase FLPP-1 were contracted since 2004 and the activities are still ongoing.

The principal objectives of the different phases are summarized in the following figure, acc. to ESA:

Period 1 2004-2007	 Preparation of the down-selection of RLV system concepts driving the technology developments Preparation of experimental vehicle concepts Assess evolutions to reduce the cost of current ELVs
Period 2 step1 2006-2009	 Provide technical elements for decisions in 2008 Preparation of NGL vehicle concepts (ELV, RLV) down selection Perform associated technology activities focussing on demonstrators (propulsion, cryogenic stage, re-entry, materials and structures)
Period 2 step 2 and Period 3 2009-2013	 To be revised as a function of the selected scenario Finalisation of the initiated technology demonstrators Updated mission requirements for the NGL Final recommendation of one NGL concept

FIG 6. Objectives of the FLPP phases source: ESA, 7.3.06

Initially it was emphasized to put the focus of the investigations on re-usable launch vehicle (RLV) elements, in order to close the lack of knowledge in Europe on this subject. In particular it was intended to investigate RLV-relevant techniques with an Intermediate Experimental Vehicle IXV, a re-usable re-entry vehicle launched as an orbiter on a next generation launcher.

The existing knowledge on elements for a new Expendible Launch Vehicle (ELV) should be investigated with less effort during the beginning of FLPP. A decision towards one of the two concepts to be developed as Europe's Next generation Launch Vehicle (NGL) – RLV or ELV – was planned at the end of phase 2.

But meanwhile most of the member states are convinced, that an RLV will not be cost-favourable for the next future. Market studies, based on present and expected commercial launch demands, extrapolate a potential launch frequency for Arianespace, which does not justify the by far higher development and qualification costs for an RLV compared to a competing ELV concept.

Although not directly combined, the IXV was affected from this re-orientation, too. Moreover, there is still a non-conformance between ESA and CNES concerning the transfer of investigation results of the Pre-X, a French-national programme to develop an experimental re-entry vehicle, similar to the former US X-38 project. Requirements and objectives of Pre-X and IXV match together pretty well, so that the start-up and progress of an IXV could benefit from this data transfer to a great extent. But the work share and the responsibilities will need to be agreed between the parties.

With the ESA ministerial conference late 2005 and subsequent add-ons signed in 2006, the budget for the decided second phase of FLPP is as follows:

System Studies	6%
Cryogenic Upper Stage Technology CUST	8%
Propulsion	
Expander Cycle	26%
Main Stage Prop.	21%
Solid	1,2%
Materials & Structures	6%
Opto-Pyrotechnik	1,0%
Acionics & GNC	0,4%
Other Technologies	0,6%
Re-entry Demonstrator IXV	18%
Technik-Budget	278,4 M€
ESA Administrat. Budget	11%
total	312,6 M€

FIG 7. Break-down of FLPP-2 budget source: DLR, 17. 4. 2007

The biggest portion of this budget is contributed by France with 31%, followed by Italy with 23% and Germany with 22%. The remaining 24% are signed by other ten European countries: Austria, Belgium Denmark, Ireland, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland.

Germany has differntiated its special interests in the different topics as indicated in the following diagram:



FIG 8. FLPP-2 source: DLR, 17. 4. 2007

Hence, main German contributions will be expected in the topics Cryogenic Upper Stage Technologies CUST, propulsion techniques and testing of the 1st stage main engine as well as in expander cycle of the upper stage. Smaller contributions are dedicated to system considerations, specific topics in materials & structures and to the IXV.

2.3. ACEP Programme

When released with the ministery conference end of 2005 with a duration until 2010, the Ariane Consolidation and Evolution Preparatory Programme has been subdivided into three parts:

- Modification of components, in order to <u>consolidate</u> the today's performance and reliability of Ariane 5
- Performance of investigations and studies, in order to prepare necessary <u>evolutions</u> of Ariane 5, enabling to match the market demands beyond 2014
- Adaptation of Ariane 5 to upcoming specific scientific missions

Especially the need of the A5-ML programme (see following chapter) has introduced some changes in detail, but the principal lay-out of ACEP is still valid.

The information summarized with the following subchapters has been given by ESA.

2.3.1. Slice 10 Subsequent Phase

A first set of improvements, started within the former slice 10 programme, should be concluded now

within the ACEP budget scheme, as "batch 0"-improvements. These are:

- remaining PA1*) qualification reservations
- consolidation activities on Vulcain 2: LOX pump dynamic seals, LH2 pump diaphragm, side loads, one single flight acceptance firing test for production engines
- flatness issues on launcher stages
- JAVE non linear analyses
- POGO ESCA
- BME strength test
- reduction of propellant residuals on ESCA (thermal residuals)
- optimisation of EPC LOX propellant gauges
- performance optimisation by calibration of Inertial platform SRI thermal deformation after ESC-A filling

*) PA1 = Production lot A1

2.3.2. ACEP batch 1

A first batch of consolidations is ready to be contracted. Relevant negotiations and adjustments between ESA and the the prime contractor Astrium are running. Addressed items will be:

Launcher Level Activities:

- Synthesis Engineering
- Robust purge connector
- VEB/ESCA Cavity retro diffusion
- improvement of EPC bulkhead robustness
- ARF design improvement
- SCAR Piloting mode
- Thermal Icing consolidation
- ESCA Separation System SSS (separate contract)
- Payload Adaptors ACU PAS (separate contract)
- JAVE reinforcement
- **Propulsion Level Activities**
 - Vulcain 2 CC NiPP+
- Optimisation of pre-lubrification of HM7 LH2 pump seals
- RPH Bearing improved characterisation
- Replacement of flat seals
- HM7b feed valves V28/V30 design

improvement

- HM7 engine transient and combustion stability

- Database evaluation for improved margins

Evolution topics:

- Herschel Planck mission
- LTAS demonstration
- New On Board Computer

The hardware changes will be implemented via two launchers:

- 1st PA2-launcher (L539) is targeted to fly early 2008 the new VEB FP structure together with welded boosters
- 2nd rank launcher L546 for a flight in 2009 with new purge connector, ARF improvement and reinforced EPC bulkheads

2.3.3. ACEP Further Batches

After contracting of the first "consolditation" batch, further "evolution" batches will be defined in detail and contracted to industry. These further batches shall comprise:

- C13.8 Chugging
- C15 Helium Consumption (flight & ground)
- C18 Ariane-5 Flight Exploitation
- C20 Ariane-5 Ground Segment (accomp. of flight activ.)
- C23 MPS Pressure oscillation improvement
- System activities
- System Robustness (SG-1-10, damage tolerance, etc)
- C5.2 Modif. of V11/V17 (joint de boisseau)
- C14.8 VEB/ESC-A Thermal
- C14.9 VIRH additional testing
- E4.2 Demo flight for satellite link
- E12 EPC Dome (spin forming)
- E13.5 Activity JAR EAP or JAV EAP TBC
- E13.6 New JAVE Study
- E14 Evolution of other Elem./Equipments (Bradford)
- E9.1 System follow-up for Evolution activities
- E9.2 Galileo Studies
- E9.4 Group SG-1-10
- E4.1 LTAS TM by S/C link System/stage activities
- C13.5b CC liner life optimisation
- E13.4 Options EAP A5ML
- E13.3 C2 BME delta funding (instead of BMA redesign)

Note:

E9.3 Cryo stage activities and new launcher studies: the RFQ has been sent to Industry, activity to be contracted ASAP in the frame of A5-ME phase 2

2.4. A5-ME

This last note gives already a link to another programme, emerged in autumn 2006 due to necessities for improvements: ARIANE 5 mid-life A5-ML, now renamed to ARIANE 5 mid-life evolution A5-ME.

During the A5-ML workshop in September 2006, a variety of modifications have been proposed by industry to the different subsystems of Ariane 5. From those, the workshop's steering committee

categorized 3 levels of feasibility / interest:

- C1: coping with Ariane-5 Mid-life Evolution objectives
- C2: potentially contributing to Ariane-5 Mid-life Evolution objectives
- C3: not coping with A5Mid-life Evolution objectives

In order to prepare potential evolutions for a decision with the next ministerial conference in 2008,

- Activities shall be conducted in 2007 for potential transfer of C1 and C2 candidates towards the "A5 ME reference".
- These results become basis for the catalogue to be decided at MC 2008

It has to be noted:

- Pure cost reduction measures are not sufficient for implementation in the A5-ME programme.
- Activities in 2007 up to mid 2008 will be covered partly by budget initially foreseen for ACEP programme.
- A new upper stage concept ESC-X (expander cycle, new upper composite) has been already decided as "reference"; the activities for this item are covered within FLPP-2.

The various improvement proposals have been categorized by the steering committee as follows:

Category 1

- System: GNSS navigation, additional kickstage
- Central main stage EPC: improved front skirt
- Booster: steel case, segments 2 and 3 overloaded, nozzle, aft skirt and DIAS modification
- Upper stage ESC: versatility
- SEL: OBC, Li-ion battery
- Ground segment: payload encapsulation, GH2 venting

Category 2

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- EPC: bulkhead spinforming, Vulcain 2 evolution
- SEL: opto-pyro technique, SRI, hybrid navigation
- Ground segment: ZL-access, test benches, DAAR integration

Category 3

- Booster: steel 2 segmented, CFRP 2 and 3 segmented case, adapted nozzle
- Low-cost initiator, TBI barrier

3. OTHER PROGRAMMES

3.1. Clipper/ ACTS/ CSTS

The Clipper Programme was already discussed in 2004 between the Russian Space Agency (Roskosmos) and the European Space Agency (ESA) within the FLPP programme. Based on an envisaged cooperation between Roskosmos and ESA, the initial mission proposal was to develop a manned space vehicle with the goal to transport astronauts to the International Space Station (ISS) and also to return them from the ISS. The design approach was based on a lifting body re-entry vehicle, see following figure. During the discussions, starting from 2004, the shape of the vehicle was varied, especially and size of the regarding shape wings. Unfortunately end of 2005 at the Ministerial Conference the ESA member states could not be convinced to join the program.



FIG 9. Klipper model – manned re-entry vehicle

Subsequent, the program was reshaped and re-named to "Advanced Crew Transportation System" (ACTS) with the main goal to modernize the Soyuz capsule and to launch it on the Russian Soyuz launcher. Roskosmos and ESA agreed to run a first study phase for about 2 years to define the mission needs and to derive the system level requirements. Later a Russian internal competition was performed to decide the type of the vehicle. Three proposals were evaluated: a capsule, a lifting body with foldable wings and a winged re-entry vehicle – see figures 10 to 12.

Further mission related characteristics to be decided were the launcher and the payload capabilities for delivery and return. In some derived scenarios a moon mission was optional included with a cargo carrier, which was planned to deliver the necessary consumables and propellants for long term travels of astronauts to the moon and beyond.

After some refinement of the content, an agreement of the European industrial lead and the participants were found, the program proposal was renamed to Crew Space Transportation Study (CSTS).



FIG 10. Proposed capsule concept by Krunichev Source: Krunichev/ESA



FIG 11. Proposed "MAKS" concept by Molniya Source: Molniya/ESA

Right after the start of the procurement process it turned out that a re-iteration on system level was necessary before further program details can be developed. At the moment the CSTS program is just about to be started. The European team is set-up and the Russian team is presently in the formation status. The envisaged budget is about 18 M€ with contributions from Belgium, Italy, Germany, France, and Spain.



FIG 12. Proposed Klipper concept by Energia Source: Energya/ESA

4. CONCLUSION

The ESA Ministerial Conferences in Edinburgh 2003 and in Berlin 2005 have decided launcher-relevant evolution / development and demonstration programmes, which turned out to need time for their inauguration and for releasing the work contents. Meanwhile, these programmes as ACEP, FLPP 1 and 2, etc. have been started.

In addition, modifications on the Ariane 5 launchers have to be introduced very carefully, in order not to disturb a now successfully operating launch system. Therefore, ACEP and especially A5-ME have been re-oriented partially.

Concerning the separate CSTS development line, "Air and Cosmos" reports on July 6th 2007, that the work-shares have been agreed and the contracts are prepared. The Russian partners, however, need still a couple of months to consolidate their industrial team. But it is expected, that an appropriate defined project can be proposed for the next Ministerial Conference in 2008.