DEVELOPMENT OF THE POLAR SATELLITE SERVICE*

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Abstract

Small satellites, with total mass less than 250 kg, is rapidly gaining worldwide interest. So far, however, launch costs have prevented widespread development and use of such satellites. If launch costs are considerably reduced and a reliable launch vehicle is made available, this will promote the development of new and cheaper design and manufacturing methods. This will in stimulate the small satellite market.

The Norwegian Space Centre (NSC) and the Swedish Space Corporation (SSC) is studying the design of a dedicated launch facility for small polar orbiting satellites, called the Polar Satellite Service (PSS)

This paper discusses the development of PSS. It focuses on the development of the first European facility that will offer integration, launch and operation of small satellites in polar orbits. PSS is offered for USD 5 mill., including launch vehicle.

PSS will be a cost-effective and flexible service based on existing infrastructure of Andøya Rocket Range (ARR) (69°17'N, 16°01'E), the launch facility of the Norwegian Space Centre (NSC) and Esrange (67°56'N, 21°04'E), the operations center of the Swedish Space Corporation (SSC). A mobile down range telemetry station located at Svalbard (78°03'N, 13°37'E) can be included when required.

The availability of a dedicated launch vehicle is essential when a low cost service is established. Different launch vehicles have therefore been assessed, and requests for proposal have been issued. From the replies, the new PacAstro's PA-2 launch vehicle was found to be most compliant with the requirements. PA-2 launch vehicle can place 225 kg in 750 km circular polar orbit.

Technical, operational, market and organizational aspects of PSS were studied in 1992/93 through a feasibility study conducted as a joint Norwegian-Swedish project. The first launch is planned for 1996 if the development starts in 1994 and if the market develops as expected.

Keywords:
Polar Satellite Service, Launch facility, small satellites, Launch cost, Launch vehicles.

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1. INTRODUCTION

NSC and SSC is jointly evaluating a possible development of a launch service for small polar orbiting satellites, called the

Polar Satellite Service (PSS). Based on existing infrastructure at ARR, TSS and Esrange, the goal is to create a low-cost and flexible service for integration and launch of such satellites.

The background for this is the new developments in space technology which have opened for a reduction in the size, weight and complexity of satellite systems, and thereby have reduced the requirements to facilities required for orbital launches. As a result of this, it is now possible to expand the capacity of existing sounding rocket launch facilities so they, with limited investments in new infrastructure, can be used for satellite launches.

Consequently, the NSC and SSC are studying technical and financial aspects related to PSS development. The development philosophy behind PSS is based on a maximum reuse of existing facilities to minimize the investments and the operational costs, and the goal is to create a dedicated, cost-effective service for small satellite.

2. THE PSS CONCEPT

PSS shall market and perform, on commercial terms:
- inexpensive, reliable satellite launches to polar orbits using the PacAstro rocket from Andøya

to companies and organizations worldwide, but specifically the European market, for space activities,

so that:
- the customers need for reliable space transportation capability is satisfied

Preliminary market studies have indicated that there is a market for small satellite systems and that this market will develop further, if a PSS like service is made available.

3. TECHNICAL SOLUTION

3.1 Existing infrastructure

The geographical location and the facilities already available at the ranges, makes it relatively easy to expand their joint capacity to a launch facility for small polar orbiting satellites.

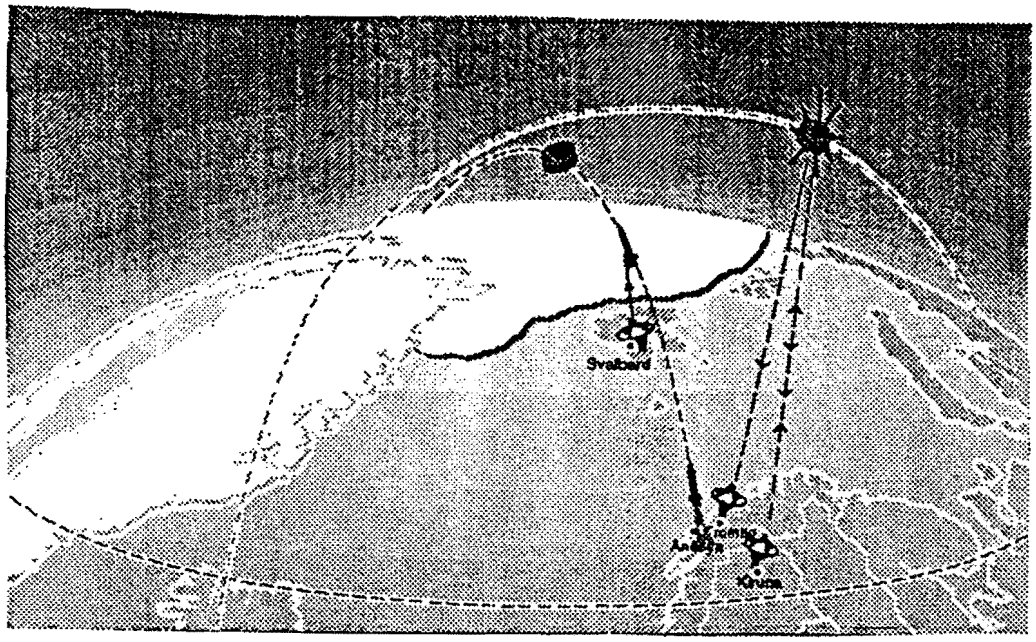

Figure 1. Location of PSS Infrastructure.

This will, however, not be sufficient to achieve the necessary reduction in operation cost to make the service attractive. A dedicated low-cost launch vehicle must be defined and operations cost must be reduced.

The study has shown that it is advantageous if a small satellite service such as PSS can offer a turn-key service, covering the launch vehicle, together with launch- and flight operation. Integrating all services in one system is required when an effective, minimum cost service is developed.

NSC has together with SSC, therefore, suggested to expand the existing sounding rocket facilities at ARR and Esrange to facilitate orbital launches. Based on available installations, an extensive network of ground-based stations can be made available to support PSS. In addition to the existing facilities at Esrange and ARR, a mobile station at Svalbard is included for down range, orbit determination, when required. This is illustrated in Figure 1. The proposed combination of stations gives PSS a unique market position.

3.2 Technical solution

The baseline for the ongoing feasibility study has been to maximize the use of existing infrastructure, in order to reduce investment cost and to create a functional and operational solution that minimizes operational cost.

The project team has therefore reviewed the available sounding rocket infrastructure at ARR and Esrange. The ground segment uses different stations to achieve the desired functionality. With respect to flight operation, remote stations and TM backup, several alternative scenarios are currently being evaluated and discussed by the project group.

The total investments at ARR and Esrange is estimated to approximately 8 MUSD and development time is 2 years. Hence, it is planned to conduct the first orbital launch in 1996, if the development starts in 1994. The investments is expected to be financed by NSC, SSC and national/Nordic institutions if PSS operation is shown commercially liable.

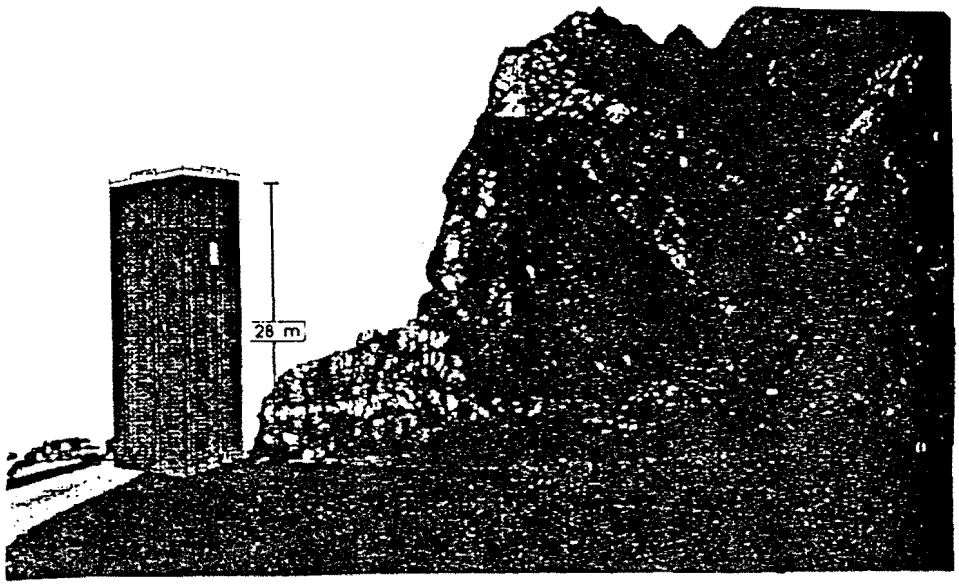

Figure 2. PSS Launch Facility with Assembly Tower.

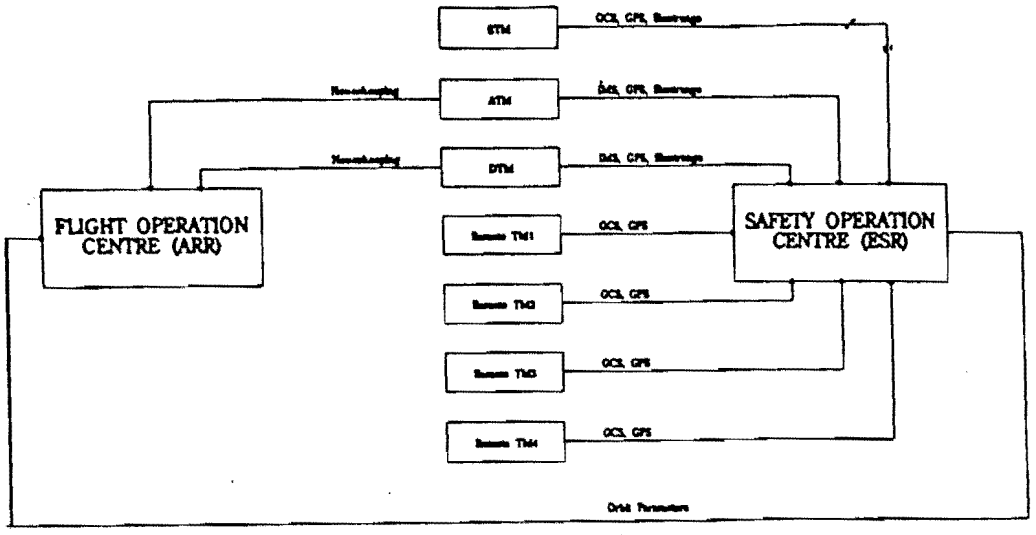

Figure 3. Suggested Data Flow, Data Reception/ Monitoring/Orbit Verification.

A detailed technical specification of available and planned infrastructure is not included in this paper. For details, reference is made to the range users handbooks available for ARR and Esrange, and to PSS technical reports.

The PSS operation is based on the availability of infrastructure and expertise at the ranges. Due to its geographical location, ARR is the launch site, and facilities required for this is developed. The major development is related to a new launch pad and blockhouse facility planned for Kleiva which is an area close to the existing facilities.

The assembly tower will be based on the Maxus tower design, recently constructed at Esrange. The tower is shown in Figure 2. In addition a new payload integration and test facility is planned, but it will not be constructed unless vertical integration is required. Launch operation and control will take place in an upgraded facility at the existing range.

At Esrange, the major upgrades are related to the Safety Operation Centre (SOC) which includes the Maxus flight operation system. Substantial developments have been made of this system. Software and thrust termination systems (destruct) must be adopted to a satellite launch.

During a launch campaign the vehicle will be tested and readied for launch by a launch vehicle team consisting of representatives from the launch vehicle provider, ARR and Esrange.

Final count down is initiated from ARR and monitored from the Safety Operation Centre (SOC). After green status from all systems the launch operation initiate the launch. The suggested data flow for data reception/monitoring/orbit verification shown in Figure 3.

TM housekeeping signals from the launch vehicle are received at both Andøya and Esrange to establish a redundant system for command destruct, which is suggested located at Esrange. Communication between the sites will be through two 64 kbit data links. TM coverage from Esrange is shown in Figure 4.

In the baseline for the feasibility study, it is proposed to use DLR/MORABAs mobile equipment, if required. The German radar can, for example, be used for first stage tracking. Establishing international cooperation like this is essential when a low cost service is established.

3.3 PSS operation

PSS will offer its services on a commercial basis. Market studies indicates that there is a substantial market for this service if the total cost can be kept at a level of approximately 5 MUSD.

The users of PSS will face a company jointly owned by NSC and SSC (and possibly other investors) which is responsible for the total service. This company will then procure services and rent infrastructure from ARR and Esrange, and also be contractually responsible for the launch vehicle procurement.

3.4 Range safety constraints

PSS is contrained to launch vehicles having a total of approximately 40 tons of net explosives. This is due to ground safety considerations, and distance to the range infrastructure and near by inhabited areas.

The design criteria on orbital capacity is set to satellites with a total mass of 225 kg into a 750 km sun synchronous (98^{o} inclination), circular orbit.

Flight safety evaluations have to be carried out separately for the launch vehicles, but are not expected to impose additional constraints.

4. THE LAUNCH VEHICLE

The operation of PSS require access to a reliable low-cost launch vehicle with a capacity to place approximately 225 kg in orbit. Such a launch vehicle does not exist today. The nearest are the airborne Pegasus vehicle from Orbital Sciences Corp. and Scout from LTV Inc. Being quoted at USD 12-14M, both these vehicles are by PSS considered too expensive for small scale missions such as the ones planned for PSS.

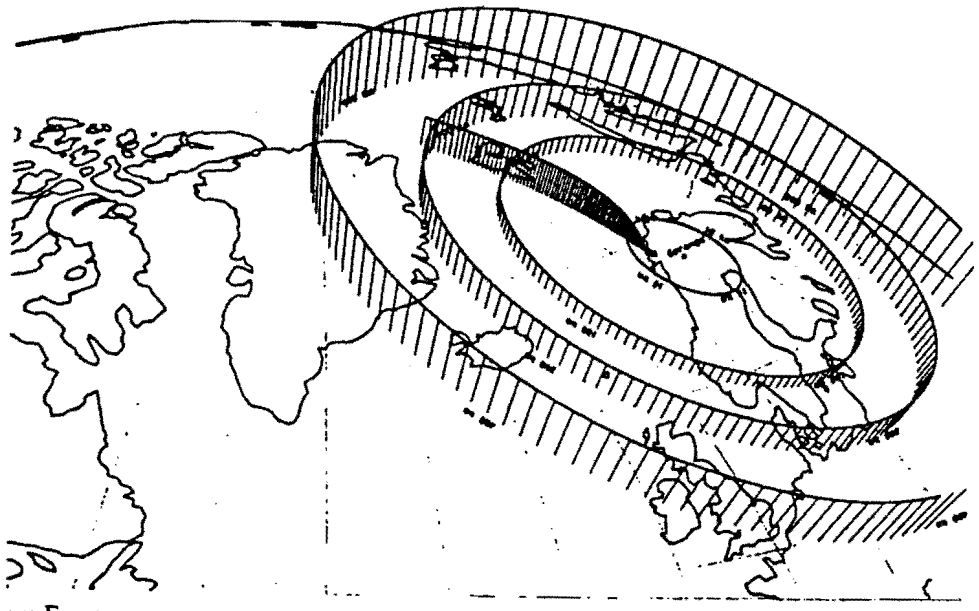

Figure 4. Coverage from Esrange .

Members of the PSS team issued a request for proposal to a number of launch vehicle candidates. The PA-2 vehicle from PacAstro was fond to be most complient with the actual requirements.

PA-2 is a two staged liquid fueled (liquid oxygen and kerosene) vehicle, using engines manefactured by TRW of USA. Potential suppliers for all the major subsystems of this vehicle have been identified, and they all have flight heritage. The capacity of the PA-2 vehicle is shown in Figure 5. The PacAstro development is a joint effort by PacAstro and SSC.

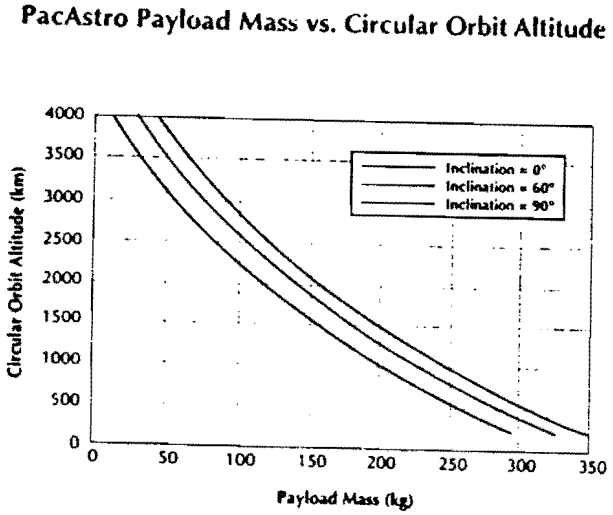

Figure 5. Orbital Capacity.

The PacAstro development program is estimated to 20 MUSD including three launches. It will be initiated when the funding is secured, which is expected to take place during 1993.

It must be emphasized that the availability of a low cost launch vehicle is critical for PSS. This is the only way to establish a service within the actual economical framework.

5 . IMPACT DISTRIBUTION

To evaluate various range safety aspects, impact distributions must be calculated for different situations. At NSC, impact distributions have been calculated by trajectory simulations using a Monte Carlo method. A set of input data for the 3D Rocket and Satellite Simulation program (ROSS) has been constructed to represent a two stage liquid fuel launch vehicle for small satellites.

It is believed that these data are close enough to real launchers to give a fair estimate of the flight safety parameters. Simulations have been run to show the impact distributions for a number of different failure cases.

Figure 6 show the expected dispersion areas for failures occurring at arbitrary times during the two burning phases of this fictive vehicle. The vehicle is launched with an azimuth of 350° to a circular orbit of 750 km. This launch scenario gives an inclination of approximately 98°.

The failures were simulated as follows: A random thrust deflexion between 0° to 40° at accident time in a random pitch and yaw direction, followed by random pitch and yaw rates between 0 to 5 deg/sec until thrust shut off which is assumed to occur after a reaction time and 5 seconds during first stage burn, and after 10 seconds during second stage burn.

6 . CONCLUSION

The Norwegian Space Centre and the Swedish Space Corporation are jointly investigating the possible development of an integrated service for launch and operation of small polar orbiting satellites, called the Polar Satellite service.

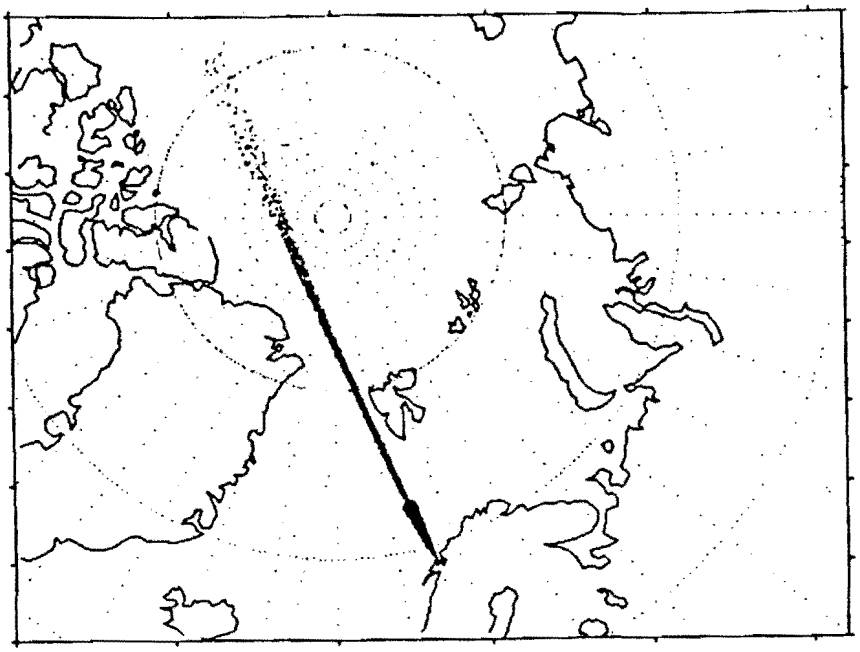

Figure 6. Expected Dispersion.

Preliminary technical and operational studies show that it is feasible to establish such a service based on existing infrastructure at the Andøya Rocket Range and Esrange.

It has been shown that existing sounding rocket facilities and satellite ground stations can be upgraded to obtain satellite launch capabilities at a modest cost. The main success criterion for a dedicated launch facility for small satellites is, however, the availability of a reliable low-cost launch vehicle, and the possibility of using existing infrastructure so that minimal investments and incremental development is feasible. An expanded feasibility study and a functional requirement specification is now under way.

In the design of the Polar Satellite Service incremental upgrade of existing facilities is suggested, to exactly meet the requirements from a launch facility for small polar orbiting satellites. It is necessary to minimize the investments and utilize existing technology to create a flexible and low-cost service.

The design philosophy is based on cost-effectiveness, cost reduction and flexible operation. To achieve this, it is necessary to develop a:

- service based on existing infrastructure, experience and technology,
- mission suitability through dedicated launches and launch vehicle with high flight frequency,
- service that utilize geographical and operational advantages,
- service dedicated to specific users and market niches,
- flexible, turn-key solution, low cost launch service, including launch vehicle,
- service with an affordable mission cost (including launch cost to orbit),
- short implementation time,
- simple planning methodology and small infra-structure,
- simple technical and management organization.

REFERENCES

1) Haugen, E, **Safety Evaluations at ARR**. Internal studies, Draft Report Norwegian Space Centre, March 1993.

2) Högman, U, Marcus, L, **Report Flight Operation PSS**. Internal studies, Draft Report Swedish Space Corporation, Esrange, April 1993.

3) Skatteboe, R, **An integrated launch facility.** Presented at the 4th European Aerospace Conference, Paris France, May 1991.

4) Skatteboe, R, **Launches of micro-satellite from a Norwegian Facility.** Presented at 10th ESA/PAC Symposium on sounding rockets and balloon and related research, Cannes France, May 1991.

5) Skatteboe, R, **New developments at the Andøya Rocket Range.** Presented at the Study Meeting for Electronics and Data, Lillehammer Norway, June 1991.

6) Skatteboe, R, **Conceptual study of a Northern Satellite Service.** Paper at the 5th AIAA/USU conference on small satellites, Salt Lake City, Utah USA, 1992.

7) Thomassen, H, **PSS investment breakdown Study.** Internal studies, Draft Report Norwegian Space Centre, Andøya Rocket Range, April 1993.