CRCSS
Space Industry News

FedSat launch issue

Cooperative Research Centre for Satellite Systems Number 95, March 2003

FedSat reaches 4th month of operation

FedSat, Australia's research microsatellite, was successfully launched from Japan on 14 December. Since then it has been commissioned and daily returns scientific data.

The launch, aboard Japan's National Space Development Agency (NASDA) H-IIA rocket flight 4, occurred in perfect weather conditions at the Tanegashima Space Center, 900km south-west of Tokyo. FedSat was launched piggyback with the large Japanese satellite ADEOS-II, as were two other Japanese microsatellites.

The initial stages of the mission were declared successful after FedSat was deployed into orbit 31 minutes after launch, and began communicating with its groundstation in Adelaide about 10 hours later.

CRCSS Executive Director Dr Brian Embleton congratulated the teams of researchers who have worked on FedSat for the past five years.

"FedSat is the first Australian-built satellite in more than three decades, and seeing it launched successfully has been a tremendous experience for the researchers across Australia who have worked so tirelessly on this project," Dr Embleton said.

"This is the dawn of a new era for space engagement in Australia." ●

Above, left and right. Tanegashima Space Center, Japan, 14 December 2002. Launch of NASDA's H-IIA F4 rocket, carrying ADEOS-II, FedSat, WEOS, and Mircolabsat.

Below, FedSat in space. Successful deployment of FedSat about 30 minutes after launch.

More articles inside.

Launch video available via:
http://www.crcss.csiro.au/launch/launch.html

Pictures courtesy NASDA.

In this issue ...

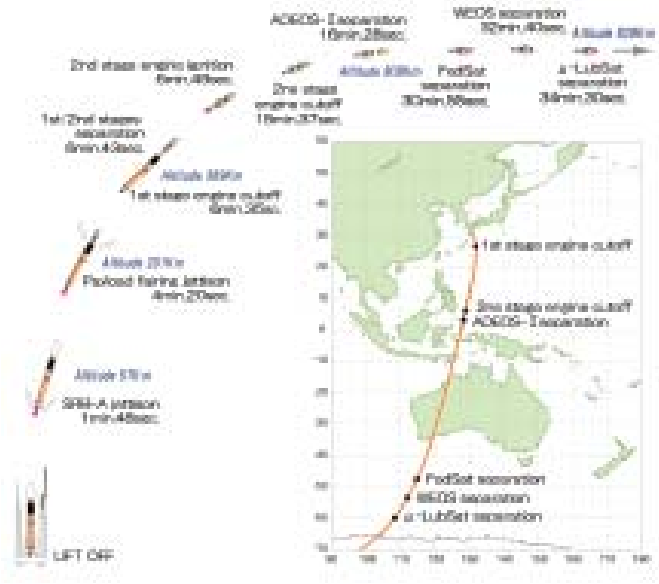

Diagram showing H-IIA launch sequence, 14 December 2002, and the satellites' deployment trajectory. Courtesy NASDA.

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Cooperative Research Centre for Satellite Systems
GPO Box 1483
Canberra ACT 2601 Australia
Phone: 61 2 6216 7270
Facsimile: 61 2 6216 7272
http://www.crcss.csiro.au/
e-mail: firstname.lastname@csiro.au

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Editors: **Wayne Deeker & Jeff Kingwell**
CSIRO Telecommunications and Industrial Physics

Editorial consultant: **Brian Embleton**
Design & photography: **Wayne Deeker**
Admin. assistant: **Louisa Lo**

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Masthead and "Variable Orbits" graphics design, Wayne Deeker.

Cooperative Research Centre for Satellite Systems

Mission
The Cooperative Research Centre for Satellite Systems (CRCSS) delivers sustainable advantage for Australian industries, universities and government agencies involved in services based on applications of small satellites.

The Centre commenced on 1 January 1998, under the Cooperative Research Centres Program of the Commonwealth of Australia. Objectives of this program include:

- to contribute to national objectives, including economic and social development;
- to stimulate broader education and training experience;
- to capture the benefits of research and strengthen links between research and its commercial and other applications;
- to promote cooperation in research.

The core participants of the Centre comprise:

University of South Australia
CSIRO
Queensland University of Technology
University of Technology, Sydney
Auspace Limited
Vipac Engineers & Scientists Limited
University of Newcastle

The Centre also includes as supporting participants:

Defence Science & Technology Organisation
La Trobe University
Codan Ltd.
DSpace Pty Ltd
Curtin University of Technology

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http://www.crcss.csiro.au/spin/spinmain.html

FedSat exceeding expectations

Just three months after launch, FedSat is supplying a wealth of information to Australian and international researchers.

"All of the experiments on board are functioning well and the amount of valuable data from the satellite grows daily," said Executive Director Dr Brian Embleton.

Highlights of the satellites performance to date include:

- The NewMag magnetometer is a very sensitive and rapid-sampling device for measuring the strength of the Earth's magnetic field. FedSat's polar orbit crosses important regions of the low-altitude magnetosphere, so NewMag effectively gains a window into the whole magenetosphere. Initially the device is being used in conjunction with ground-based instruments in the Polar Regions, as part of an international research program involving scientists from Japan, Australia, the USA and other countries.

- Commencement of experiments aimed at developing new types of computers for use in space. FedSat's "High Performance Computer" uses re-configurable logic which enables operators in the ground to make changes to the on-board hardware. This feature could be exploited in new-generation satellite computers which can be effectively "repaired" by ground command after being damaged by the effects of radiation.

- FedSat's Global Positioning System receiver is supplying navigation information to help in tracking the satellite. Centre researchers use the past position data, in a mathematical model, to accurately predict the satellite's future position. Data from the receiver are also used to probe the electron content of the ionosphere, an important factor for determining the efficiency of communication systems that rely on transmission through the region.

- FedSat's primary ground station in Adelaide is communicating with the satellite every week day and most weekends. The innovative fast-tracking Ka band ground station in Sydney was opened in late February. Together, the ground stations have proven the successful operations of the complex, multi-band communications system on board.

- The satellite's Star Camera has been brought into regular use to accurately determine the orientation of the satellite. This step increases the scientific value of the data obtained from NewMag.

"The commissioning stage of testing the performance of a new satellite often lasts many months," said Satellite Program Manager, Mirek Vesely, "especially when the satellite is the first one an organisation has built. FedSat is probably more complicated than any other satellite of its size, but we have managed to orient it correctly, we have extended the 2.5 metre boom holding the magnetometer space science instrument, and we have progressively brought each payload into operation, all in a relatively short time. We have found that the power system is better than we had expected, so we are able to run the experiments for longer than we had planned."

FedSat was one of four satellites launched from Tanegashima Space Center, and was the first foreign satellite launched by the H-IIA rocket. Under a special arrangement between the CRCSS and the National Space Development Agency of Japan (NASDA), the launch service was supplied in exchange for scientific data from the satellite. ●

A wonderful place

Jeff Kingwell

This, which I calculated to have been my ninth, was perhaps the sweetest of all visits to Tanegashima.

I first came here in 1989, when I performed a study on rocket launch weather forecasting operations under a Japanese Government research award. I was one of the first foreigners to work at the Space Center, and I will never forget thinking "wouldn't it be nice to come back again, with an Australian satellite, and to see it launched from this most beautiful of launch sites?"

I learnt some of the local history: the fact that this was the place that Europeans and Japanese first met, in the early sixteenth century, and that within a year of the first sighting of the Portuguese muzzle-loading rifle, the Tanega clan's metal-workers had reproduced the device, setting off a technological change that would soon make it possible for the Tokugawa shogunate to overthrow the constantly warring feudal lords and finally unite Japan.

Living Japanese style in the NASDA apartments, I made many friends, the closest being Atushi Ohkuma, then my next-door neighbour, *sensei,* language instructor and singing partner. Ohkuma-san re-entered the story during the FedSat launch campaign, when as the CRCSS Tokyo Representative he prepared the way for the import of the satellite and its two tonnes of ground support equipment, and did all the invisible but essential background work needed to clear customs, meet Japan's strict regulations on the satellite's pyrotechnics, and arrange the shipping to the launch site.

Having lived here before and speaking a little bit of Japanese, the experience as part of the FedSat launch team with Brett Robertson, Andrew Bish [*SpIN* 88, 90], Carl Todd, Mirek Vesely and Mike Petkovic [*SpIN* 80] was all the more enjoyable. Some of my favourite karaoke bars had changed, but new ones had opened, and the choice ▶

of suitable songs had greatly expanded. My Japanese fluency generally decreased in proportion to the input of *shochu*, the local liquor of choice, made from one of the island's other most famous products, sweet potatoes. This sometimes induced great hilarity on the part of locals and my colleagues alike, but I will spare the details of the most infamous incidents!

My memories of Tanegashima are precious, and now include seeing my earlier wish fulfilled as the H-IIA flight, with FedSat on board, became the fifth launch I had participated in at one of my favourite places: surely one of the most beautiful and friendliest islands in the world. I'd like to think that the visits to the shrines that we all performed on the morning prior to the launch really did have some effect! And we didn't in the least bit mind leaving behind the obligatory offerings of finest Nansen *shochu*.

As always, one of the biggest joys of the launch campaign was working so closely with Japanese friends and colleagues, whose guidance and hospitality were essential to FedSat's success. Our small team learnt a great deal from them, not only on technical matters but also customs, language, humour and superior karaoke skills! ●

FedSat for me

Andrew Bish

The launch, seperation and first acquisition of FedSat was the highlight of my professional career, even more exciting than arriving in Antarctica for my winter stint.

After working on FedSat since the end of 1999, a lot was at stake for me as we sped along the dark windy road from the hotel to the NASDA launch complex. Once more my mind pointlessly went over the list of pre-launch tasks we had performed during the past 40 days on Tanegashima. Had we done everything? It didn't matter any more as FedSat was sealed and ready to go.

As the sun rose over the ocean and launch pad, we were already wide awake and observing the NASDA pre-launch sytem checks. All systems were go for a 10:30 launch and the pre-launch weather balloons confirmed the weather was stable; we were go. At 10:20 Mori-san took us to the roof of the blockhouse and we waited as the countdown progressed, watching the Nitrogen vapour pour down into the bay around H-IIA-F4. I couldn't hear the countdown very well but knew it was about to happen when the high-speed camera next to me started up.

The launch was spectacular. Seeing a rocket, that you had to climb 9 storeys to get to the Fairing (where FedSat was located), just take off like a firecracker is amazing: the sound still impacting on your chest at 3km and the vapour trail pouring out of the rocket as it screams off into orbit. We stayed and watched as the Solid Rocket Boosters separated and the rocket faded into the distance, then rushed down the ladder and back inside to see the down-loaded Telemetry and Rocket status.

My anxious wait for the second "victory lap" of H-IIA-F4, which would bring the telemetry video of the micro-satellite seperation sequence, was only outlived by my exuberance at seeing FedSat separating from the Payload Adaptor Fitting. We had all worked so long and hard to see FedSat in space, and it was a fitting goodbye to see her finally released into space, slowly spinning with the Earth as a backdrop.

However, it wasn't over yet. Ringing Carl Todd back at the Adelaide Ground Station to tell him FedSat had successfully separated made us realise the rest depended on the FedSat team. Had we completed the final closure correctly, the battery charging and installation, the S-Band antennas, the solar panels, the pyrotechnics? What about the testing and repairs in Canberra, especially those last minute repairs and modifications, would the Ground Station work? It made for an exciting and anxious wait that afternoon, so much so that Brett Robertson and I arranged to be on the teleconference with the Ground Station during the initial acquistion. The teleconference was to be in STA2, our home for the past few weeks, and Tsunami-san went to a special effort to allow us in late that night (though he had a severe cold). The Japanese were as enthusiastic as we to see it all work.

That night we watched FedSat approaching Australia on Brett's STK screen and with excited anticipation listened on the phone to the hive of activity happening in Adelaide. As FedSat blipped into range on the screen and the guys at the groundstation went into track mode, the tension went up to max; Jeff and Mike seemed quitely confident but Brett and I ... well, that was another story. The first few minutes went by with no contact, we could hear Terry Kemp going through the "sweeping" motions, but to me it sounded like the flat line on a heart monitor, there was no signal. What had we done wrong? Was it the S-Band system? Some stuff had seemed a little weird during testing but I had attributed that to my lack of sleep. Now I was sure it had failed. How could you possibly communicate with a tiny satellite 800km away anyhow? The whole thing seemed ludicrous, I wanted to jump out the window (its a long way down from the 2nd floor of STA2).

Then we heard an excited commotion over the phone (not sure what they said but I knew what it meant). They had acquired it, it worked! We jumped up and down and congratulated everyone, Jeff cracked open the bottle of wine and we had a celebratory drink while looking at the downloaded data Carl had emailed us. FedSat looked well and seemed to have plenty of power to boot. Eventually we went home that night and dreamt of FedSat; actually I didn't dream, I couldn't sleep until 6 am.

In some ways this was the end of the FedSat project but it was also the beginning for Operations and Science. A lot more remained to be done but FedSat was up there and working. ●

FedSat timeline

August 1996: Science Minister McGauran announces Australian microsatellite project.

July 1997: Bid for CRCSS sucessful. FedSat preliminary design work begins.

January 1998: CRCSS formally commences. FedSat payload selection finalised.

September 1998: UK company selected to provide FedSat platform.

February 1999: FedSat platform contract signed.

July 1999: FedSat launch formally discussed with NASDA. FedSat design committed to piggyback launch.

November 1999: NASDA H-II rocket malfunctions. NASDA cancels H-II flights and moves forward replacement H-IIA series. FedSat launch rescheduled

July 2000: FedSat platform tenderer ceases trading. Alternative plans for completing FedSat in Australia.

December 2000: Further revision to NASDA launch schedule.

May 2001: FedSat engineering team assembled at the project office, Auspace, Canberra.

August 2001: First test launch of NASDA H-IIA rocket successful.

December 2001: FedSat enters assembly, integration and test phase. NASDA continues testing of H-IIA series, FedSat launch rescheduled.

February 2002: AusIndustry provides A$ 2.0 million FedSat grant. Second test flight of NASDA H-IIA series successful. FedSat integration begins.

June 2002: FedSat assembly complete. Testing phase begins.

July 2002: FedSat vibration testing at VIPAC in Melbourne, modifications needed.

October 2002: Final FedSat testing complete. FedSat flown to Japan 31 October.

November 2002: Integration of FedSat with ADEOS-II and H-IIA rocket.

December 14: Launch of FedSat.

December 14: Communications with FedSat established.

December 16: FedSat commissioning continues smoothly, "detumble mode".

December 23: Payload testing begins. "Pointing mode" (correct attitude) established.

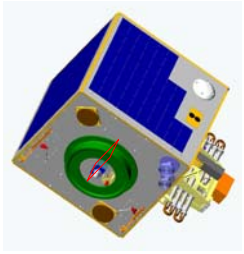
December 30: Initial GPS satellite position determinations analysed from GPS data.

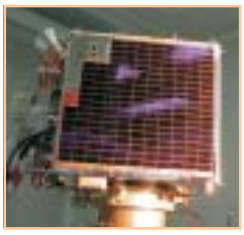
January 13 2003: Magnetometer boom deployed successfully.

7 February 2003: Operation for 50 days, two passes per day. "All's fine".

26 February 2003: Ka-band groundstation commissioned at UTS.

March 2003: In-orbit commissioning phase to conclude. FedSat available for research.





FedSat, H-IIA rocket showing ADEOS-II and FedSat, and December launch. Courtesy NASDA.

5th CRCSS Conference

The CRCSS held its 5th annual conference at the Technology Park Conference Centre, adjacent to the University of South Australia campus, Mawson Lakes, Adelaide, from 17-21 February. About 80 CRCSS delegates and visitors attended.

Senator Grant Chapman addressed the conference opening dinner. He congratulated the CRCSS on its achievement of launching and operating FedSat [page 1], which he said had been a historic moment in Australian science. Senator Chapman said Australia could now stand proudly with other space-capable nations. Senator Chapman acknowledged the support the National Space Development Agency of Japan (NASDA) provided the CRCSS regarding the launch of FedSat.

At the conference opening session, Dr Brian Embleton, CRCSS Executive Director, said he was pleased to welcome delegates under these happy circumstances, where for the first time in five years, the CRCSS was able to do research with its own data. Dr Embleton acknowledged the large team of CRCSS engineers who had made that possible, and reiterated the CRCSS' thanks to NASDA for the launch.

In the first session of the Conference, FedSat engineering manager, Mirek Vessely, covered history of FedSat development to 14 December. Andrew Bish [*SpIN* 88, 90], engineering team member in Japan, discussed the technical launch preparations [page 4]. Brett Robertson, also a FedSat engineering team member in Japan, discussed how the CRCSS had resolved post-launch issues including the in-orbit wobble. Chris Evans mentioned the stresses and excitement of how the CRCSS ground station in Adelaide had acquired FedSat immediately after launch; the CRCSS team located and communicated with FedSat on the first attempt. Dr Stephen Russel [*SpIN* 90] explained the commissioning and testing phase since launch. The first step involved using magnetorquers to brake FedSat's slow tumble, to where deliberate pointing is possible. Dr Russell said FedSat was in good health and the concerns about FedSat's power levels hadn't eventuated.

Professor Brian Fraser [*SpIN* 88] evaluated FedSat's initial magnetometer data. He said the data were reasonably consistent with what the CRCSS expected, and that the minor anomalies could be removed following further calibration of the instrument. Professor Bill Cowley said the ADAM payload [*SpIN* 89] tests would be complete in

March 2003. Dr Rod Walker [*SpIN* 83] presented the FedSat's GPS results, with data beginning 8 days after launch. He said that from then to February GPS position information had been available for 51% of FedSat's operating time, and that despite minor glitches, the GPS data received so far had been better than expected. Dr Yanming Feng [*SpIN* 82, 86] said he had found the FedSat GPS data adequate for precise orbit determination but improvements were expected. Precise orbit determination is mathematically more complex, needing more accurate data. However, Dr Yanming Feng said further work should mathematically improve the quality of FedSat's GPS data.

Dr Anwar Dawood [*SpIN* 83, 91, 93] said that the HPCE payload is healthy and had successfully processed uploaded stack commands and implemented reconfiguration files, but that there were some remaining tests to be conducted involving the Adelaide team. Professor Sam Reisenfeld [*SpIN* 83] described the Ka-band Earthstation [page 8].

A contingent of 10 Japanese representatives also attended the conference, presenting papers about some of NASDA's many satellite projects. These included techical displays on Microlabsat, one of the microsatellites launched with FedSat. ●

Far left, above, Tadaaki Kurosaki, Hiroshi Kikuchi, Kiwao Shibukawa, Tateo Goka, Moritaka Nagasaki. Far left, below, the CRCSS FedSat groundstation control room, University of South Australia ITR, during a FedSat pass. Left above, Tadakaki Kurosaki, ADEOS-II Project Manager, presents a model of ADEOS-II to Brian Embleton during the conference. Left, NASDA team demonstrate Microlabsat model and telemetry data. Right, Toru Yamamoto, Matsuaki Kato, Nobuhiro Takahashi, Mashiko Nagai. All photos, Wayne Deeker.

Ka Earthstation commissioning

The CRCSS team at University of Technology, Sydney [*SpIN* 83, 89], celebrated the commissioning of the FedSat Ka-band Earthstation on 26 February. Federal Minister for Science, Peter McGauran, attended the function along with senior CRCSS and UTS representatives at UTS' Kuringai campus in north Sydney.

Associate Professor Sam Reisenfeld said that other Ka-band experts around the world had expressed doubts about the "impossible goals" of running a Ka-band system from a small satellite. Ka-band is a very high frequency part of the spectrum, so such systems have a very narrow beam-width, requiring small dishes but extremely accurate pointing. That's difficult enough to achieve, and all but impossible in a small satellite context involving very low power and fast movement across the sky. The satellite's actual hypersonic orbit speed means extremely high Doppler shifts. Also its relative speed across the sky (up to 180 ° in 15 minutes) requires very fast mechanical tracking and the ability to maintain tracking lock through an overhead pass (the fastest part of the arc), plus the relative movement causes very rapid changes in apparent Doppler shift (Doppler rate). All these problems together require extreme pointing accuracies from the groundstation, and the ability to maintain that accuracy as the satellite zooms across the sky.

Nevertheless, despite the enormous difficulties, Professor Reisenfeld and team have been successfully operating and commissioning the Ka-band system since soon after FedSat's launch. Minister McGauran congratulated Professor Reisenfeld and the CRCSS for being the world's first organisation to achieve that highly significant goal on a small satellite platform.

Professor Reisenfeld said the CRCSS team at UTS had also achieved the world's most accurate Doppler tracking system [*SpIN* 89].

"These features of the FedSat Ka-band system mean the CRC can participate in extensive markets for high capacity satellite commercial and defence communications applications," said Professor Reisenfeld, "plus markets for satellite design, systems engineering, frequency tracking, antenna steering, modem design, signal processing, and Earth station software."

The Ka-band groundstation is located on the library

Above, Science Minister Peter McGauran addresses the gathering at UTS. Below, Professor Reisenfeld (left) demonstates the Ka-band groundstation terminal to UTS Vice-Chancellor, Professor Ross Milbourne.

building at UTS' Kuringai campus. In March the CRCSS established a second Ka-band Earthstation adjacent to the FedSat main groundstation at the Institute for Telecommunications Research at the University of South Australia in Adelaide. With these two Ka-band groundstations complete, over the next two years the CRCSS Ka-band team will begin fundamental research into the properties of low power Ka-band signals on small satellites. ●

Above, the UTS FedSat team. L-R: Jeffrey Tsui, Chris Chapman, Youn Sik Kim, Kowk Chung, Sithamparanathan Kandeepan, Peter Farleigh, Thorsten Kostulski. Absent: Ray Clout.

Below, Peter Farleigh demonstrates the FedSat Ka-band antenna on the roof of the UTS Kuringai campus.

Photos: Wayne Deeker.

Goodbye Brian

Dr Brian Embleton, CRCSS Executive Director, is taking leave at the end of March pending his retirement later in the year. Here, in this final interview with Wayne Deeker, he reviews the last five years and talks about the future.

What were the most challenging points for you and how did you sort them out?

The most challenging bit was recovering from the failure of SIL to deliver a space qualified, fully tested platform, to which we would have been able to integrate our payloads. That was about two years into the contract, and by then the design and planning had gone too far to allow us to make any significant changes to the planned hardware and software. If it hadn't gone that far, we would have done things differently.

It was challenging on two fronts. We had to come to a group understanding of what was required — engineering challenges, design documentation, software development. Secondly, it left us dreadfully short of funds.

And how did you feel at the time?

It made me feel that I needed to work harder than ever to gain the cooperation and support of the partners. Without that, we were not going to meet our objectives.

I never doubted that we would actually finish the job. I had enough confidence in the engineering team and their abilities that they could take over the incomplete platform, complete the design, complete the construction, and write the software. But I knew that to do that we hade to have a new level of cooperation, and that happened. The partners came on board with additional resources: new people, students, post-graduates, and staff. These people moved to Canberra, undertook specific aspects of the project, completed them, moved out, then somebody else came in for a new task, completed that and moved out. So we had a series of young engineers and scientists rolling through the FedSat Project office in Canberra. That's why we needed to raise the level of cooperation, to complete the platform.

I realised I felt that in a way our credibility was on the line. Not that we had been criticised at all. There was advice from people in the field who had been building satellites that it would have been unlikely that they could have done it. So, it was our only chance. And I guess that's how I felt too: we only had one chance to build the satellite. If we didn't do it, then it probably would have been another 30-40 years before that ever happened again. So we had to do that, whatever it took, basically. But I think the solution was the right one: appeal to the partners to increase their commitment, and that's what happened.

What did we learn and how would we do it differently next time?

We have had it confirmed that we have the capability to produce small satellites. We learned a lot about microsatellite technology, thermal models, mechanical models, vibration requirements, various payloads and the system. That's what we learned in a very real sense.

I also learned that maybe small satellites should not be so complex. We should keep it simple in future, say two years from design to launch, a relatively simple bus with one or two payloads, a prime mission objective in terms of delivering a service. FedSat is an extremely complex satellite with six payloads, because our objective was to produce an orbiting laboratory for all the CRCSS research needs, though it was a great training ground and learning exercise.

There are lots of things we'd do differently. Hindsight is a wonderful thing. I could speak for hours on what we'd do differently. First and foremost, we'd build our own platform from the ground up. We believed we didn't have the time to do that. We wanted to put all our energy into the smarts, into the payloads, into experiments. We believed that if we did that we wouldn't have time to build the platform (bus) as well.

There is one thing I would do differently next time, and that is to ensure the ground segments and the space segments are treated equally from the very beginning. There are reasons why we treated them as separate entities, primarily because when we planned the project the platform and part of the ground segment were going to be provided through a contractual arrangement. We could focus only on the payloads and some aspects of the ground segment. But having had to take responsibility for the total system, we realised that the whole ground segment should have been part of the overall planning because it had to change as well. I did not appreciate the degree of the changes we needed to make throughout the whole system.

Sure we'd do things differently, but essentially what we did led to success so there has to be some merit in it.

What have the CRC and FedSat achieved?

What we have done is repaid trust and confidence of the CRC Program and the Innovation Access Program in AusIndustry, they funded us.

Secondly, we've earned the respect of the international space community. FedSat is an international space mission, Australian led and Australian managed. I said international because it carries payloads from University of California Los Angeles, Johns Hopkins University, NASA, and Stellenbosch University in South Africa. All contributed to the development of payloads in collaboration with our research teams. FedSat has the South African designed and built extendable magnetometer boom. It's carrying Canadian attitude control system technology, the

first of that type in space, designed for one of their own missions but prototyped and flying on FedSat. So we earned the respect of the international community.

The third point is we made history in Australia, we made history for Australian engineering and science. Never before has such a dedicated group of Australian scientists and engineers been able to develop a satellite of a complexity of FedSat that has been successfully placed in orbit and operating. That's another achievement of FedSat. We are now in a position to provide research data, not only to our partners and Australian collaborators, but to the international science community, in specific areas where the scientific data are of value to the community as a whole.

I believe that we have also inspired the passion of young engineers and scientists to work in space science and technology. And it's only through inspiring young people that are able to attract them into these challenging areas.

What is coming up for the CRC?

We have an orbiting laboratory in space, our first priority is to secure resources so that we can maximize the effectiveness of that laboratory and benefit from the research it allows us to do. That's the first priority. The second is to build on the success of FedSat. I think we have only a six to twelve month window for capitalising on the value of FedSat as an engineering system, our orbiting laboratory in the sky.

I am not going to convince politicians to put hundreds of millions of dollars into a satellite industry. We will however be seeking an investment of the order of tens of millions as we focus on achievable outcomes throughgh affordable access to space. We don't have a national policy, I would like the CRC to provide some sort of backdrop as Australia thinks about its future in space. The CRC is there, it may not be the perfect model, but it is there demonstrating its potential, those capabilities are in place, and until something else comes along, I don't think there is anything better to represent Australian activities in space. In a sense, the CRCSS is the de facto Australian space agency.

The CRCSS involves twelve organisations, representing a degree of collective wisdom. But the funding is vitally important and that's the glue that holds the group together. There is no pretense that the CRCSS is anywhere near generating revenue to sustain its activities in space science and technology. There will be examples where we can move towards that, but we are still a way off from it. We still need government support, industry commitment, university commitment, and the support of government research organisations, like CSIRO and Defence. I think the way FedSat is going could encourage government to think about renewing its commitments to space science and technology.

Beginning with when you arrived in Japan in December, tell us about the milestones, culminating with the launch, and how you felt about those.

The first milestone happened a few days before I got there, that was the fit check. We only worked from plans, and had never had the opportunity to put the satellite into the payload bay and see how it physically integrated with the other satellites around it. That went perfectly.

When I arrived, I felt relief that the launch was on schedule. Many people attend many launches but few people are there to watch them, as per original schedule. So we were fortunate. You have to remember that on the day I arrived in Japan, ARIANNE-5, with 2 intended geostationary communications satellites, failed to reach orbit. So there were lots of nervous people in Japan. It was an incredible relief to see FedSat launched.

The next milestone was related to the whole H-IIA campaign, beginning with the release of ADEOS-II. When ADEOS separated, of course there was a great feeling of satisfaction from our Japanese colleagues. Then we had to wait 90 minutes for the orbiter to come back around over the ground station at Japan, and downlink the video images of the status of the 3 micros. That's when we saw FedSat deployed, then WEOS, then Microlabsat, so we knew all four satellites, ADEOS and the three micros, had been successfully deployed. So that was the great moment, to know that we had a satellite in orbit.

Then the next major stage was 10 hours after launch when I had a call from the ground station in Adelaide, to say that they had picked up FedSat. We were all terribly concerned that we needed to pick up FedSat as quickly as possible and ideally to get it on the first pass. Ten hours, six orbits, before it came over the ground station, we knew more or less where to look, but there was certain amount of error in time and space. With support from the Japanese Launch Agency and NORAD, our people at the ground station were able to find FedSat, switch it on, and get it under control. And when we did it, that just incredibly affected everybody on the project.

What's next for you?

I am planning my retirement. That's going to mean getting my golf handicap down, playing a lot of tennis, and spending some time at home relaxing, doing a bit of remodelling, rebuilding. I'll take a break for about 6 months and then I'll assess my future. I've got no plans other than to take a break from what I am doing.

And it is a good time to break because I don't want to commit another 5 years. I'd love to help plan the future, but I wouldn't have the commitment to the full implementation. Therefore it's appropriate that new faces, new ideas, and a new management style comes in during this important planning phase.

So it's a good time to take a break. I might want to keep in touch with the Board sometimes and play a role in the future, but that's up to them.

SpIN and the CRCSS congratulate Brian on his career [see *SpIN* 77], especially the last five years culminating in the successful launch of FedSat, and we wish him well in his retirement. ●

Welcome Andrew

Dr Andrew Parfitt [*SpIN* 85] from CSIRO will be the new Chief Executive Officer of the CRCSS, following the retirement of Dr Brian Embleton [page 10]. Dr Parfitt was until recently head of the CRCSS' Advanced Radio Frequency Systems (Ka-band transponder) program.

Dr Parfitt received his BE and PhD degrees in Electrical & Electronic Engineering from the University of Adelaide. From 1987 he was with the Defence Science and Technology Organisation at Salisbury in South Australia where he worked on antenna and radar related problems. In 1992 he joined the academic staff of the Electrical & Electronic Engineering Department at the University of Adelaide. From 1995 to 1997 he served as Associate Dean in the Faculty of Engineering at the University of Adelaide, responsible for undergraduate and curriculum matters. In 1998 he joined CSIRO Telecommunications & Industrial Physics in Sydney, where he was Leader of the Space and Satellite Communication Systems Team. He has been responsible for a number of antenna and radio system research programs and contracts, including the development of antenna proposals for the Square Kilometer Array Radio Telescope and the construction and commissioning of the FedSat Ka-band transponder system.

Dr Parfitt has published over 100 technical papers in conferences and journals, mainly in the areas of antenna design and computational electromagnetism. He is a senior member of the Institute of Electrical and Electronic Engineers, and currently holds the office of Chairman of

the New South Wales Section. Dr Parfitt holds adjunct academic appointments at the University of Adelaide, the University of South Australia, Sydney University and Macquarie University.

Dr Parfitt told *SpIN* he looks forward to taking up the challenge of building on the success of FedSat by strengthening the CRCSS' research and engineering programs, developing new commercial, and strategic linkages and working towards a better framework for supporting space and satellite initiatives in Australia. ●

Andrew Bish award

On the 13th of March, Andrew Bish, CRCSS engineer from the University of Newcastle [page 4], received an award from the university. The Vice-Chancellor's Award for General Staff Excellence recognised Andrew's contribution to the FedSat project over the previous 4 years.

Ghostly asteroids clue to missing matter

Astronomers have lost thousands of comets. A University of Melbourne physicist thinks are just invisible. And some may be on a collision course with Earth.

Dr Robert Foot suggests many of the missing comets could be made of an exotic "mirror matter", a type of invisible matter that a small group of physicists believe could be the elusive "dark matter". He says mirror matter may come in chunks big enough to form comets and asteroids, maybe even planets.

"Most tantalysing, is evidence that our planet is frequently bombarded by asteroids made of mirror matter, causing puzzling events such as the devastating Siberian explosion in 1908 and similar, but smaller recent events in Jordan and Spain," he says.

The theory of mirror matter has been around for decades. The case of the missing comets has baffled scientists nearly as long. Yet, if Foot is right, the two mysteries may be connected.

Dr Foot says mirror matter is not visible because it doesn't interact with ordinary photons. But he says it should have mass, so it may interact with ordary matter via gravity and perhaps a new force. These interactions could allow heat to build up within the mirror body, causing it to explode. It would also make the mirror body visible. He says if the Tunguska and other events were results of mirror space-bodies, then tonnes of mirror matter might lie hidden just below the surface of these sites. Nobody has looked.

He says the missing comets might be mirror comets with embedded ordinary matter. Once they have passed the sun, their ordinary volatile components progressively burn off, leaving an invisible mirror matter core. He says this would explain why so many simply fade away.

Foot has outlined his theories and those of other mirror matter proponents in a new book, *Shadowlands: quest for mirror matter in the Universe.* ●